POWER

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Hasty Judgment Is Rash

"DON'T take any notice of what he says, he's only a helper anyway. He's been in the business a few days and now wants to give suggestions and advice."

One sometimes hears remarks of this nature even among machinists and engineers, but it behooves us all to think twice before rendering such a judgment. We may be quite unaware of important facts concerning the person offering advice, and as sometimes happens, the best of help and suggestions on various subjects may come from unexpected quarters.

All good ideas and suggestions do not necessarily come from the people who have grown gray in following the same line of business.

Years ago a lighthouse was to be built in the English Channel to mark a dangerous spot. One of the most noted architects and builders of the day was entrusted with the work, and so confident was he, because of his previous record and experience, that upon its completion he said that he hoped to be in the lighthouse in as bad a storm as could be. He got his wish, for he was in the lighthouse and lost his life when it was beaten down during a heavy gale. It was a watchmaker who designed the foundations to hold the next lighthouse upon that spot and it exists to this day as a monument to his thought and skill. This is the Eddystone Lighthouse outside Plymouth Sound.

Not many years ago a traveling piano salesman thought he had an idea which might be turned to practical use and today that same idea has developed into one of the most efficient and practical of rotary pumps, and its manufacturers are kept busy trying to keep pace with the orders.

In the issue of Oct. 15, appeared the following news note:

"Twenty nine college professors from 25 different colleges in 19 states carry their dinner pails and earn 20 cents an hour in local industrial plants. They have forfeited their vacations that they might get more practical experience."

Suppose, for instance, that the helper referred to should happen to be one of these professors who have sacrificed their pleasure to gain practical experience and so combine practice with theory. The man to whom he offers advice may be able to say at once, by reason of years of practice, that the suggestion is not practicable, and explain very simply why. By so doing the business of engineering as a whole is benefited to that extent, for the professor is shown something he had not known before and in the course of his teaching will be able to reach and instruct a far larger number than the lone engineer who was really responsible for the change in the professor's ideas.

On the other hand the suggestion may cause the engineer, even with his years of practice, to see things in quite a new light and help him to reason out many a difficulty for himself, the better for the argument advanced in just the one case.

It was rather a long shot from watchmaker to lighthouse designer and from traveling piano salesman to pump designer, so who knows but that the man tendering advice may prove your benefactor instead of a beneficiary.

When advice is offered think it over carefully. Do not let the seeming unimportance of the person who offers it cause you to depreciate an idea that is really worthy and practical.

[*Contributed by P. J. Leaman, S. S. Texan, Puerto Mexico, Mex.*]

Remodeling a Hotel Power Plant

By W. E. Barney

SYNOPSIS—A description of some of the difficulties encountered in remodeling a hotel power plant while continuing to supply the house with power, light and heat. The work consisted not only of changing the piping and substituting a new for an old engine, but also of removing three boilers and installing new ones.

The Copley Square Hotel, in Boston, Mass., was built 20 years ago. At this time there were installed a 700-light gas meter, two 60-in. by 12-ft. horizontal return-tubular boilers, two hydraulic elevators, two high-pressure tanks 36-in. by 12-ft. double-deck type and one 6x7-ft. upright discharge tank. A central-station company furnished the lighting. Its lines came in at the top of the building and ran down through the three light shafts. The three-wire system had a double-throw switch at the top of each shaft, link fuses at each floor, and link fuses in each hallway.

When a fuse burned out the engineer clung to the seventh-story window casing with one hand and put a fuse in with the other.

These link fuses were all over the house, although the wiring was concealed, except in the basement and kitchen. Some of these circuits were connected with fuse wire instead of being wired properly. Later on an engine and belt-driven, 300-amp., 110-volt generator was installed. There was one feed pump for boilers.

When the writer took charge of this plant in 1909, three boilers were bulged and one had no brickwork under the lugs; the combustion chamber was 18 ft. deep and an 18-ft. by 24-in. smoke flue ran to a 30-in. stack. The draft was poor and the boilers were filled with scale ⅜ in. thick. There was no cleanout at the base of the chimney. Most of the piping leaked at the joints, and a siphon was kept running 24 hr. per day to keep water out of the engine room, and then it was necessary to walk on a 2-in. plank as the water, grease and oil stood about 1 in. deep.

The help left when repairs were commenced, thinking life too short to start remodeling the plant. Renewing valve seats and taking out old pipe was no small task, as, figuratively speaking, there was enough pipe for two similar hotels. The main pipes in the heating system were in fair condition. On one side I found three sizes of pipe in the main line from 4 in. down to 2 in. The returns were underground and some of the pipes were leaking, which made it difficult to get steam to the top of the building.

The first winter it was necessary to work day and night. Eventually it was decided to sell an old Corliss engine and other old machinery and install a new engine. The problem of removing the old 16-ft. split flywheel without tearing down the building had to be solved. After measuring the skylight in the sidewalk, it was evident that the wheel would clear by about 6 in. After the wheel was in the pit under the sidewalk, there was 4 in. to spare. When changing the piping and heater it was found that the exhaust pipe from the engine in use was about 6 in. under the cement floor and with no drip; it ran up 2 ft. into the heater. The drips on the engine were piped to a trap which discharged into the sewer.

A new switchboard was being put in, and the inspectors condemned the wiring, which made more work. The basement was rewired, also the kitchen and air shafts, and cabinets with plug fuses were put in all over the building. When this work was going on the electric company installed a 25-kw. meter, and by running the engine 23½ hr. per day the service was maintained uninterrupted.

Connecting the different circuits was accomplished without any inconvenience to the hotel. The first month after running the new machine, and stopping some leaks, quite a saving was made in fuel. The coal bill in January, 1909, was $826.79, but in January, 1910, was only $720.33; this was better than was expected. In March, 1910, the bulged boiler No. 3 was condemned. The blow-off pipe in No. 2 was clogged solid with scale, and troubles began to increase.

After figuring the cost of opening the building to be $1500, and to repair the boiler $1000, it was decided advisable to install new equipment, for the other two boilers had lap seams and were 19 years old, so that their pressure would have to be reduced the next year. The repair bill, therefore, would be a total loss, as the plant could not be run with less than 85 lb. pressure. It was proposed to install new boilers and elevator tanks, a new elevator pump, and cut out the old annex plant. The old boilers faced toward Blagden St., and it was planned to face the new boilers toward Exeter St. at the rear of the old boilers. Bids were called for opening the building, removing old material, shoring up the building, making foundations, which must be water-tight, and for installing three 66-in. by 16-ft. horizontal return-tubular boilers, two 5x14-ft. double-deck high-pressure tanks, one 5 and 6 by 16-ft. discharge tank, one 18 and 12 by 24-in. duplex pump, one 20 and 12 by 18-in. pump, and two feed pumps.

Several contractors refused to bid, claiming it would be impossible to comply with the plans. However, in July, 1910, the work of taking down the old pipe began and No. 4 boiler was also removed, after which the first shoring started. I-beams were placed in position and the excavating for No. 3 new boiler progressed rapidly until we struck some old piles and soon had water coming in at a rate of about 500 gal. per min. A cement partition wall was built at the rear of the old No. 3 boiler so as not to flood Nos. 1 and 2. It was found practicable to run the smoke flue at the front of the boilers instead of on top and with less initial expense.

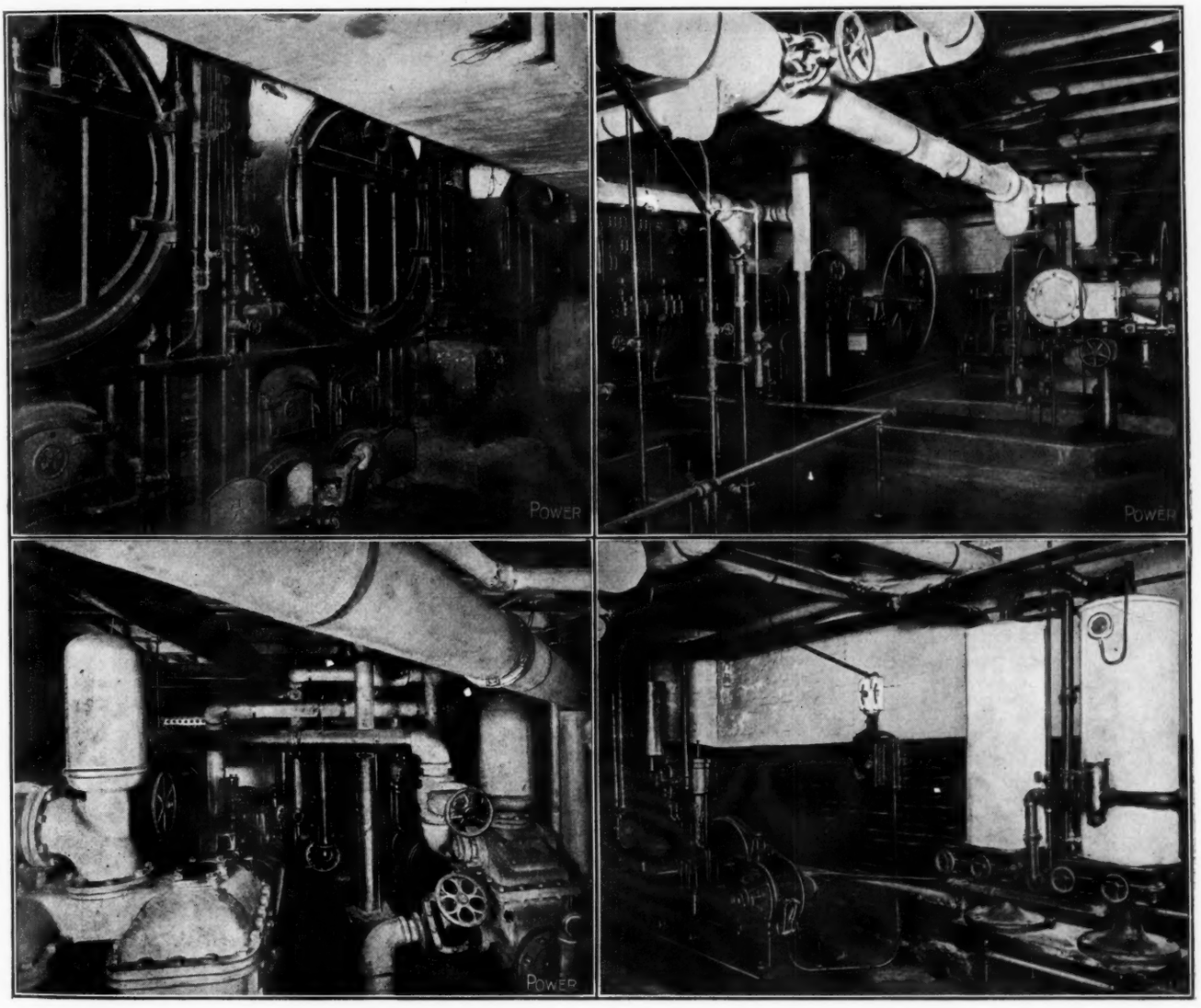
After piping the engines, the engine company wanted to equalize the machines, as the three old boilers would not make enough steam to run both engines, but with the new boiler enough steam was obtained to carry the load with a variation of 5 lb. in two 10-hr. runs. The dismantling of boilers Nos. 1 and 2 was next started, so as to shore up the building after taking down the wall to the piles; also to make a foundation for iron columns upon which 15-in. iron beams rested crosswise to hold up the building. This work had to be done before the rest of the material could be removed.

After removing the two old boilers the foundations for the new ones were put in. I-beams were placed from the inside partition wall to four piles and from these piles

too the outside building wall, going underneath the hydraulic elevators without stopping them. Then the last connection to the stack from the flue was in order. It was proposed to run the engine to furnish lights as long as we had steam and use lanterns until we finished. The size of the new flue was 36x42 in., and the work was started at midnight with a load of 100 amp., 110 lb. of steam and three gages of water, and a good fire, the elevator service was shut off, and at 5:15 a.m. the flue was connected to the chimney, the engine running all this time, the gage on the boiler showing 40 lb. and one gage of water. Although the bricks were out around the flue, the fireman was ordered to get up steam, and at 6:15 there was 95-lb. elevator service and steam for the kitchen all ready for the day's run. The brickwork was all completed by 11 a.m.

Before Nos. 1 and 2 boilers were set, the elevator service had to be removed and new tanks and pumps installed and foundations made for them. We started at midnight to take out piping, removed the elevator pump and double-deck tanks the next day, and that night built foundations for the tanks and in one week the two elevators in the hotel were running. After this the annex elevators were connected to the high-pressure tank and the annex plant shut down. All elevators were repaired, which completed the work, with the exception of a little pipe covering.

The saving in fuel was surprising, although the price of coal was 25c. per ton higher than in 1909. The fuel bill in January, 1912, was $545.82 as against $826.79 in January, 1909. With this saving of fuel and a wage of $50 per month, having let one fireman go, saving on water, oils and packings, the economy of the present plant is enough greater than before to more than pay the interest on the cost of installation.



VIEWS OF THE COPLEY SQUARE HOTEL POWER PLANT

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An open competitive examination for electrical assistant will be held on Feb. 26, at the places mentioned on Circular No. 81, issued by the United States Civil Service Commission. The salary is $1080 per annum. Applicants should be familiar with the practical side of electricity as applied to telegraph, telephone and kindred engineering and should be familiar also with the equipment and methods of installation of telephones, storage batteries, motor generators, auxiliary power switchboards, telephone switchboards and with wire and radio-telegraph apparatus. Form 1312, which can be had from the Civil Service Commission, contains the requirements for applicants desiring to take this examination.

The Field for Small Steam Turbines*

By W. J. A. London and Ashley P. Peck

SYNOPSIS—Discussion of the consideration of efficiency from the commercial standpoint and the field of application where small steam turbines are especially desirable.

The authors wish at the outset to emphasize the fact that there is a marked difference between the field and requirements of the larger and the smaller turbines. In large steam-turbine work, efficiency is of paramount importance and is the basis of all designs. The machine is developed to obtain maximum efficiency under the given conditions and no reasonable expense is spared to attain this end. In other words, the designer, while naturally building his machine as cheaply as possible, must not consider expense in construction if any cheaper design would affect the efficiency in the smallest degree.

The designers of small steam turbines are confronted with an entirely different proposition. To fulfill the requirements of the market these machines must be made in quantities. Further, they must be made to sell as cheaply as possible and yet meet certain efficiency guarantees.

Sometimes a machine will be sold on its water-rate performance. At other times steam economy is of no consequence, and then the machine is obviously sold on design or price. However, it should be understood that a standard frame must fill the requirements of both.

The duties now required of small steam turbines demand at the outset absolute reliability so that efficiency must not be considered at the expense of reliability and cost.

It is a mistake to assume that the average thermal efficiency of, say, 40 to 45 per cent. which is now obtained with small turbines operating under standard conditions is the maximum possible for this type of machine. There is no reason why small machines cannot be built to approach the thermal efficiency obtained on larger machines of 65 to 70 per cent., but up to the present this efficiency has not been demanded, nor (and this is more important) has the customer been willing to pay for it; and further, we think we will be able to show that there is no necessity for such an efficiency. The theory of the steam turbine is no longer the mystery it was ten or even five years ago and it is well known that the various makes of small steam turbines are of the impulse type, as this lends itself better to compact design, which is the prime feature of all small turbines. In the impulse type (so called) the steam is expanded in a nozzle or jet and the kinetic energy of this jet is absorbed in passing one or more times through the buckets of the turbine rotor. The efficiency obtainable by a certain design is no longer guess work and the two factors governing this efficiency are, first, peripheral speed and, second, number of stages or passes of the steam through the buckets of the rotor.

Small Impulse Steam Turbines

may be divided into two general types: single stage and multi stage. In the first the steam may pass from the jets once through the buckets and thence out, or in the multi-velocity single-stage type, the steam may reverse and reënter the rotor two or more times, its velocity energy being extracted successively with each reversal.

In the multi-stage turbine the steam is expanded successively through two or more single- or multi-velocity stages, imparting to each stage a part of its energy during expansion.

It has been demonstrated that with single-stage turbines, employing the multi-velocity principle, the maximum thermal efficiency is obtainable with only two reversals; in other words, the wheel-rim velocity must be substantially one-quarter of the steam velocity. It has also been demonstrated by Prof. Stumpf and others that an efficiency of 60 to 65 per cent. can be obtained on a single wheel. A single-stage machine running noncondensing with a wheel 2 ft. in diameter running at 2500 r.p.m. employing about three or four reversals will give an efficiency of 40 per cent. The same turbine to give, say, 60 per cent. efficiency would have to have a 4.5-ft. wheel. Experience has shown that the cost of small turbines follows very closely the square of the diameter. For example, a 100-hp. machine designed for 40 per cent. efficiency would sell for approximately one-fifth the cost of an equal capacity turbine, developing 60 per cent. thermal efficiency.

Another consideration is that in the higher efficiency turbine the wheel stresses alone would be five times those in the commercial type of machine.

Again, considering the case of a multi-stage machine, the number of stages vary inversely as the square of the velocity per stage. That is, a turbine operating under duplicate conditions to those mentioned and having a thermal efficiency of 40 per cent. would have about five stages. To obtain the 60 per cent. it would require 25 stages, giving a difference in cost practically equal to that mentioned previously for the single-stage machine.

The foregoing shows that whichever way is taken and whatever type of machine is used, efficiency can only be obtained at the expense of first cost. In large turbines, why a customer should decide on a higher-priced machine with a better water rate can easily be shown. For instance, with a 5000-kw. machine having a steam consumption of 16 lb. per kw.-hr., if the consumption were reduced to 15 lb., and assuming 10 per cent. interest on the money invested, the purchaser could afford to pay $36,000 extra.

That this argument does not hold good with the smaller units is easily demonstrated. Take, for instance, a 50-kw. generator with a water rate of, say, 60 lb. per kw.-hr. One pound saving in the steam consumption of this unit should raise the price approximately 15 per cent.

These points are brought out to show that while efficiency in small turbines is often discussed by the purchaser as of vital importance, when it comes to buying the machine he is not consistent. If the price is the same and the water rate is better in one than another he will naturally favor the more efficient machine, but does he bear in mind that higher efficiency can only be obtained at the expense of reliability? In single-stage ma-

*Abstract of a paper presented at the fifth annual convention of the Association of Railway Electrical Engineers, Chicago, Oct. 21-25.

chines the larger the wheel the greater the duties on the bearings, also the increased tendency to distortion. In the multi-stage machine the more stages the more internal glands.

Considering first the application of

Small Steam Turbines for Driving Auxiliaries

in large power plants, such as exciters, boiler-feed, circulating and hotwell pumps, it is now acknowledged standard practice in uptodate power houses to run such auxiliaries by steam and to run these machines noncondensing, exhausting into feed-water heaters. A heat balance will show that in the average power house the exhaust from the auxiliaries can all be taken care of in the feed-water heater, so that the steam economy proper in the smaller unit itself is not very important. The steam turbine is therefore being adopted more and more for auxiliary drive only because of its many obvious advantages. The increased use of superheated steam and the troubles that are experienced with it in small reciprocating engines is one of the main reasons for the rapid progress made by the turbine-driven auxiliaries. Again, the growing tendency to reduce station costs by employing cheap labor necessitates apparatus that is simple and "foolproof." The turbine resembles the electric motor in its simplicity—the lubrication and attendance being about the same, whereas the marked advantage of having the source of power taken direct from the boiler instead of through any intermediate source naturally has many advantages over the electric motor, especially when the unit is placed in the basement where electrical leaks are likely to cause serious damage.

As an approved form of prime mover for alternating-current and direct-current generators for power and light in shops, etc., and for "head-end" lighting and storage-battery charging the turbine now occupies an important position. It is compact, requiring small floor space; simple in construction; requires but little attention and practically no adjustments during long periods of operation, and has an almost negligible maintenance cost. The lubrication is entirely automatic, being of the ring-oiling or forced-feed type.

Advantages over Reciprocating Engines

A marked advantage of the steam turbine over the reciprocating engine where the exhaust steam is utilized for manufacturing purposes lies in the fact that the steam turbine delivers absolutely clean steam without any cylinder oil in it as in the steam from the reciprocating engine and without the necessity and uncertainties of oil extractors in the exhaust lines.

Another feature favoring the steam turbine is its remarkable maintained efficiency as compared with reciprocating engines. The turbine will hold its original efficiency for long periods as there is no appreciable wear on the buckets or jets, therefore, no change in shape, while the reciprocating engine depends for obtaining its guaranteed water rate, upon a minimum friction loss and absolutely steam-tight valves.

That uptodate station engineers appreciate that the reliability of the auxiliary apparatus is infinitely more important than the individual unit efficiency cannot be better demonstrated than by citing several stations where steam turbines are used for driving such apparatus as circulating pumps, the speed of which is far below that of even reasonably efficient conditions.

Several modern stations are now equipped with small turbines operating at no higher speed than 1000 r.p.m. and in one instance a turbine is installed for pump work at as low a speed as 550 r.p.m. This last machine has a water rate of 65.6 lb. as against 26.7 lb. per b.hp. that would be expected from a reciprocating engine. There is obviously only one reason why turbines were installed in these stations, and that is their absolute reliability.

We are all inclined, in looking through a power house, to consider the apparatus in the following order of importance: the main generators, the boilers and, lastly, the boiler-feed pumps. We never give the matter a thought that if the boiler-feed pumps go out of commission, the whole plant would be shut down. Again, take the question of condenser pumps. If these go out of order, on a 5000-kw. machine and the machine switches over to atmosphere, the coal consumption is increased about 3½ tons per hour.

In street-railway work the duty often put upon both the main units and the whole plant is probably the most severe of any power equipment. Particularly in the electrification of tunnels we find installations where the load will vary from zero to 3000 kw. at one jump. Imagine the effect of this on the boilers. Experience has shown that the danger due to water-hammer can be practically ignored in turbine machinery. The governing of both large and small steam turbines has been so perfected during the last few years that it is undisputed that the turbine is much better suited for sudden changes of load than any other equivalent piece of apparatus.

The abuse that small turbines will stand is often enough to surprise even the designer. We remember an instance in one of the largest power houses in the country of seeing a hotwell turbine pump in a small pit below the floor. This pit was full to the top with water, turbine and pump being entirely immersed, yet the machine was running along as if nothing had happened and our attention was drawn to the fact that there was a machine underneath the level of the water only by the surging action of the water on the surface.

Comparative Steam Economy

It is still believed by many engineers that the water rates actually obtained with small turbines are much higher than those obtained with reciprocating engines of equal power and it has occurred to us that the above arguments depreciating the importance of efficiency might be taken as an acknowledgement of this fact. True, in some cases a small reciprocating engine can beat the turbine, but generally it must be borne in mind that reciprocating engine guarantees are usually given in pounds of steam per indicated horsepower. This at best is indefinite and the depreciation and consequent impairment of efficiency in a reciprocating engine are very much more rapid than in steam turbines.

The greater steam economy of the reciprocating engine is usually unquestioned, but it is obtained with a greater investment, more attention, more floor space, higher maintenance cost and less reliability than with a turbine.

Take, for instance, a railway shop where exhaust steam is required the year around for drying purposes and during the winter months for heating, the very economy of the reciprocating engine requires using live steam from

boilers at times or continuously. Maximum economy does not always mean a low water rate in the prime mover, but is an overall item.

It may be interesting to analyze a comparison between noncondensing reciprocating engine-driven and turbine-driven generators, rated at 100 kw. normal true energy suitable for a railway shop. Assume in each case a pressure at the throttle of 125 lb. and an average back pressure at the engine or turbine exhaust of 3 lb.; 60-cycle alternating current is used. The engine would be of the simple single- or four-valve type operating at 277 or 200 r.p.m. respectively, and the turbine at 3600 r.p.m.

The water rate of a new simple single-valve engine could be taken at full load as 28 lb. and of the four-valve at 24 lb. per indicated hp.hr. Correcting this for the 3-lb. back pressure and assuming a mechanical efficiency of 91 per cent. in each case gives a water rate per brake horsepower-hour of 32.4 lb. and 28 lb. respectively. With an operating power factor of 80 per cent., and assuming a full-load generator efficiency overall, including friction and windage of 93 per cent. and 91.6 per cent. respectively, we have an approximate water rate per kilowatt-hour for the single-valve of 46.6 lb. and for the four-valve of 41 lb.

The turbine water rate per brake horsepower-hour would be 31.75 lb. at free atmospheric exhaust and with 3 lb. back pressure, 34.2 lb.

A 125-kv.-a., two-pole, 36,000-r.p.m. alternating-current turbo-alternator of good design will test to 88 per cent. efficiency at full load and 80 per cent. power factor. This gives a water rate per kilowatt-hour for the unit of 52.2 lb.

In this typical comparison, the single-valve reciprocating engine when new and operating under similar conditions to a steam turbine, will develop at full load an overall rated efficiency of 5.6 lb. per kw.-hr. better than the turbine, and the four-valve water rate will exceed that of a turbine by approximately 11.2 lb. per kw.-hr. at full load.

This saving would be important were there no uses for the exhaust steam, as there are in railway-shop practice, for the exhaust from the prime movers but rarely goes to atmosphere.

In boiler-feed pump work it is difficult to obtain information bearing on the actual water rates obtained with reciprocating pumps. The best at our disposal is the series of tests that were carefully carried out on board the scout cruisers "Birmingham," "Chester" and "Salem," which are tabulated below, and in the same table is shown the figures obtainable from turbine pumps, which show an average advantage in favor of the turbine pump of about 31.8 per cent.

WATER RATES OF SMALL TURBINES

	Steam Press., lb.	Back Press., lb.	Gal. per min.	Head, ft.	(Recip. Pumps) W.H.P. Water rate, lb.	(Turbine Pumps) W.H.P. Water rate, lb.	Improvement in favor of turbines per cent.
Birmingham...	183	6	329	488	83	61.8	25.5
Salem.....	203	6	193	690	91.8	61.2	33.4
Chester.....	187	6.7	219	610	101.0	64	36.6

With reference to the general subject of steam consumption and the statements sometimes made that the small turbine is passing, say, twice as much steam as it should, it may be interesting to review the principle governing steam consumption in small turbines with special application to Napier's simple formula:

$$W = \frac{PA}{70}$$

where

W = Weight of steam per second, lb.;
P = Absolute steam pressure, lb.;
A = Area of orifice, sq.in.;

for the flow of steam through nozzles cannot be used to greater commercial advantage than it is at present. This formula has been proved so many times to be approximately correct that it is a pity it is not more extensively used to compute the steam consumption. Most small turbines now operate with a terminal pressure at the jet of about 0.58 of the initial pressure, so that this formula can be readily applied to any machine and the steam consumption determined by placing a gage in the steam ring.

The maker could be called upon to give the number and size of the jets and in this way an instantaneous reading could be taken showing the amount of steam passing at any one time. If this were done, less claims would be made that a turbine is passing more steam than the makers claim for it.

By a slight modification of the constant 70 in Napier's formula for various jets, figures can be obtained as accurate as is possible by actual measurement. In a series of tests carried out on a certain machine, in seven readings with a ring pressure of from 40 to 150 lb., the maximum discrepancy between the calculated and the actual results was 1.3 per cent. and the mean over all the readings, 0.457 per cent.

The actual figures obtainable on test and those calculated are as follows:

Napier's Formula	Actual Tests	Per cent. Variation
2028	2043.6	0.8
1264	1248.0	1.3
1935	1934.0	0.0
2625	2638.0	0.5
1905	1906.0	0.0
3047	3066.0	0.6
2272	2272.0	0.0
		3.2
	Average...	0.457

Since this paper was prepared with special reference to railway-shop work, the subject of condensing steam turbines has been touched on but lightly, as we understand that almost universally power equipments for railway shops are operating noncondensing in view of the many uses for the exhaust steam.

The steam turbine, like the air brake, the steel railway coach, the locomotive superheater and other improvements of recent years in railroad practice, has succeeded in breaking down the traditional conservatism which marks "something new" in all mechanical undertakings, and this is not surprising when it is recalled that the first steam engine, dating back to a century before the Christian Era, was nothing more or less than a steam turbine. The rapid introduction and commercial success of the large power turbine in common use today, rendered the introduction of the small turbine but natural in every way, and as a substitute for a reciprocating engine it has an assured and prominent position.

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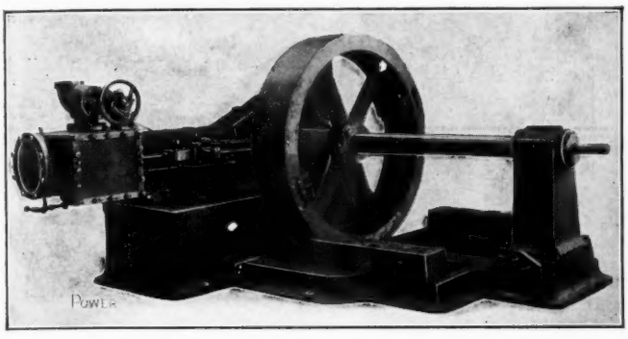
There are two causes for a belt not running true upon properly built pulleys mounted upon correctly aligned shafting. The belt may not have been made straight in the first place, or the ends may not have been joined squarely. Otherwise there may have been a lack of uniformity in the texture of the hides from which the belt was made; belly leather toward one edge and flank leather toward the other, and the two stretching unequally.

Redesigned Brownell Engine

The Brownell side-crank high-speed steam engine, built by the Brownell Co., Dayton, Ohio, has been redesigned to embody some new features. For greater stiffness extra metal and internal ribs have been provided in the frame, which is cast in one piece. There is a chamber between the guides and the cylinder into which oil and water from the stuffing-boxes drain and are conveyed to a pan in the base of the frame from which they can be drawn off at will, filtered and the oil used again.



REDESIGNED BROWNELL ENGINE

The main babbitted bearing is made in four parts: The bottom piece is fitted to a bored seat, with tongue and groove to prevent end motion. The side pieces are adjusted by wedges at each end, bearing against distance pieces and controlled by bolts through the cap. The top piece is adjusted by liners and held down by jamb screws through the cap.

Oil grooves in the side pieces start from the upper edge but do not extend quite to the lower edge so that they must be filled before oil will be carried by the shaft to the reservoir formed by the beveled edge of the quarter box and from which the grooves in the bottom are supplied. All bearing parts can be removed without lifting out the shaft.

The solid-end connecting-rod has split boxes with wedge adjustment. The crosshead pin is held in place by a flange and four clamp bolts and is adjusted by two distance screws passing through the flange and bearing on the crosshead.

The flywheel, eccentric and governor are split so as to be easily removable.

A forged-steel valve-rod guide bar is carried in brackets and runs in a flood of oil supplied from a pocket filled by the splash system, as shown by the illustration.

A Sweet type double-ported valve, but designed without a center web, to give lightness and freedom from casting strains, is covered by a flat plate held from endwise motion by adjusting screws so that the lead can be varied between the ends of the cylinder, giving a wide range in controlling the events of the stroke. The plate is held against the valve by flat springs, bearing on the steam-chest cover, thus providing means of relief from excess cylinder pressure.

In addition, new designs have been made for an open-frame type, the same as the rolling-mill frame type of Corliss engine, with throttling or automatic governors.

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Simple Approximate Metric Conversions

BY ALBERT A. CARY

SYNOPSIS—Simple rules for quickly converting metric measurements to those of the English system with approximate accuracy so that one used to thinking only in the latter units can quickly gain an appreciation of the value of the less familiar figures. Most of the calculations can be done mentally.

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Recently the writer was professionally engaged on the European continent for the greater part of a year, where the metric system was in universal use. At first, he experienced the general feeling of vagueness when matters were presented to him in metric units, that most all do who have only used this system occasionally at home, with a conversion table before them.

No one can appreciate the fine points of this system until he can think in metric units, without regard to the clumsy units commonly used in this country, and without the necessity of making conversions. Unfortunately, for a time, one from "the States," has to convert the metric units into the system he is acquainted with, to size up their values comprehensively, and the more exactly he attempts to do this the slower he is in becoming intimate with the metric system, especially if he has to refer to reference tables frequently.

As the writer's experience in this direction may be of value to others he offers here the means he worked out for arriving quickly (and in most cases mentally) at rough approximations, which were sufficiently close to serve ordinary purposes.

Our money system fortunately educates the European visitor from this country in the elementary steps of the metric system, so when he reaches the countries using the metric system he will be sure to remember that

10 mills (milli) make one cent
10 cents (centi) make one dime
10 dimes (deci) make one unit

which unit, in our money, is the dollar.

In the metric system, the unit may be one of length (the meter);—of weight (the gram);—or capacity (the liter) and fractional parts or multiples are indicated by placing a prefix before the unit.

The prefixes derived from the Latin numerals always indicate a fractional part as

Milli $\frac{1}{1000}$
Centi $\frac{1}{100}$
Deci $\frac{1}{10}$

the same as with United States money, while the prefixes taken from the Greek numerals indicate multiples. Thus

Deca, which indicates multiplied by 10
Hecto, which indicates multiplied by 100
Kilo, which indicates multiplied by 1000

That a kilowatt means a thousand watts is familiar, so all one need remember in addition, are deca and hecto.

THE RULE OF TEN PER CENT.

Taking the units themselves, it is surprising how many are about *10 per cent. more than our own units.*

Weights

Going to the various stores one finds that the very common unit of weight in Europe is the half kilogram, which is practically 10 per cent. more than our pound.

The kilogram then, is 10 per cent. more than 2 lb., so, to convert kilograms to pounds, simply multiply by 2 and add 10 per cent.

If the weight is expressed in grams, multiply by 2 and add 10 per cent, as before, but as a gram is $\frac{1}{1000}$ of a kilogram, move the decimal point three places to the left in the final result, even if this process does prefix a number of cyphers. It is easy to multiply this last result by 7000 (7000 grains = 1 pound avoirdupois), to obtain it in grains if it is a small weight.

For example, take 85 kg.

$$85 \times 2 = 170 + 17 = 187\ lb.$$

(the error here is only 0.4 lb.) again, take 60 grams

$$60 \times 2 = 120 + 12 = 132$$

and moving the decimal point three places to the left gives 0.132 lb.

$$0.132\ lb. \times 7000 = 924\ grains$$

(the error in this case is only 2 grains).

It may also be remembered that the metric ton, which is 1000 kg. (or 2204.62 lb.), is practically the same as our long ton of 2240 lb.

Lengths

The unit of length is the meter with which an added 10 per cent. may again be used, with a very small error in the results obtained.

The meter is practically 10 per cent. more than a yard.

The use of a thin pocket rule one meter long, which can be purchased anywhere on the continent, will furnish the easiest method of converting short distances from the meter and its fractions into feet and inches; these two systems being found on its opposite sides. Such a rule measures only 8 in. long, $\frac{3}{8}$ in. thick by $\frac{5}{8}$ in. wide, when closed. It has six swing joints, is made of wood, is very light and can be easily carried in the pocket.

To return to the method of calculation; with a measurement given in meters, merely add 10 per cent. which converts it into yards. This result multiplied by 3 gives the number of feet.

For example, take 42 meters

$$42 + 4.2 = 46.2\ yd.$$
$$46.2 \times 3 = 138.6\ ft.$$

(Figured exactly, this should be 137.795 ft.)

As stated before, any fraction or any multiple of a meter is calculated the same way by taking the dimension given as though it were in meters and afterward placing the decimal in its proper position, the same as in calculating U. S. money. Thus, for 60 cm., proceed as follows:

$$60 + 6 = 66$$

As there are 100 cm. to the meter, point off two places to the left, thus obtaining 0.66 yd. or 1.98 ft. (exactly, this would be 1.9685 ft.).

Surfaces

The unit of surface is the square meter, and for its conversion to English units the 10 per cent. rule is still applicable, but as a square is of two dimensions (length and breadth), two 10 per cents. must be used to obtain square yards, and for square feet, the square of 3, or 9, is the multiplier.

Applying the rule, 42 sq.m. is converted thus:

$$42 + 4.2 + 4.2 = 50.4\ sq.yd.$$
$$50.4 \times 9 = 453.6\ sq.ft.$$

(exactly, this would be 452.08 sq.ft.).

For all fractions or multiplies of the square meter, one can proceed as before, using the expression at the start as though it were in square meters, but in pointing off the final results, it must be remembered that all these smaller or larger expressions must be squared, for while 3 ft. = 1 yd., $3 \times 3 = 9$ sq.ft. = 1 sq.yd. Thus, 1 sq.m. is composed of $100 \times 100 = 10{,}000$ sq.cm., or $10 \times 10 = 100$ sq.dcm., etc. In other words, the square being of two dimensions, one must point off twice as many decimal places as if he were using the simple linear meter.

Volumes

The unit of volume is the cubic meter, to which the 10 per cent. rule also applies, but as the volume has three dimensions (length, breadth and thickness), three 10 per cents. must be used. Also, in converting cubic yards into cubic feet, one must multiply by the cube of 3, or 27.

To convert 36 cu.m. to cubic yards, proceed, by the rule, as follows:

$$36 + 3.6 + 3.6 + 3.6 = 46.8\ cu.yd.$$
$$46.8 \times 27 = 1263.6\ cu.ft.$$

(Figured exactly, it would be 1271.32 cu.ft.)

It must be remembered that in a cubic meter (sometimes called a stere) there are

$$100 \times 100 \times 100 = 1{,}000{,}000\ cu.dcm.$$

Therefore, in making calculations for fractions or multiples of the cubic meter, by this simple rule, one must point off three times as many decimal places as for straight linear calculations, on account of dealing with a volume which has three dimensions.

Capacity

The unit of capacity is the liter, and 1000 liters equal the volume of one cubic meter. One kilogram of pure water at its maximum density (39 deg. F.) under normal atmospheric pressure (29.7 in. of mercury) occupies the volume of one liter.

For rough approximation the 10 per cent. excess rule can be used to gain an idea of the volume occupied by any number of liters, but a liter is more nearly 5 per cent. greater than a quart (liquid measure).

Thus, given 40 liters, the calculation is

$$40 + \tfrac{4}{2} = 42\ quarts$$

(exactly, this figure should be 42.267 quarts).

In figuring fractions or multiples of the liter, the decimals are pointed off the same as for lengths, as 100 centiliters or 10 deciliters equals one liter and one kiloliter equals 1000 liters.

These simple 10 per cent. rules are easily remembered and equip one to use the metric system without conversion tables with their many varied constants or multipliers.

A few other useful rules involve the figures 0.6, 1.6 and 16.

For a rough approximation of 100 km., multiply by 0.6, which gives 60 miles. In reality, it is 62.137 miles. A closer calculation can be made after multiplying by 0.6, by adding to this result one-half of the product, but

with the decimal point moved one place to the left thus:

$$100 \times 0.6 = 60$$

and half of 60 is 30, which, by moving the decimal point, becomes 3, and, added to 60 gives 63 miles.

To convert miles into kilometers, multiply by 1.6.

$$100 \textit{ miles} \times 1.6 = 160 \textit{ km.}$$

(To be exact, this should be 160.935 km.).

There are approximately 16 cu.cm. to the cubic inch; therefore divide cubic centimeters by 16 to get cubic inches. Usually it is quicker to divide twice by 4 ($4 \times 4 = 16$).

Thus, in 100 cu.cm. there are

$$\tfrac{100}{4} = 25 \text{ and } \tfrac{25}{4} = 6.25 \textit{ cu.in.}$$

(Exactly, this should be 6.1023 cu.in.).

Per contra—in 100 cu.in. there are

$$100 \times 16 = 1600 \textit{ cu.cm.}$$

(Exactly, this should be 1638.7 cu.cm.).

A number of conversions not admitting of such simple rules the writer noted on the back of a 6-in. slide-rule, which proved constantly useful. These included steam-gage readings, which are commonly indicated in kilograms per square centimeter:

14.223 lb. per sq.in. = 1 kg. per sq.c.
0.070307 kg. per sq.c. = 1 lb. per sq.in.

The rate of evaporation in a boiler is usually expressed in kilograms per square meter so, to convert this reading into pounds per square foot, multiply by 0.2048.

Dividing by 5 gives a close approximation. Thus, 20 kg. per sq.m. equals

$$\tfrac{20}{5} = 4 \textit{ lb. per sq.ft.}$$

(Exactly, this will be 4.0962 lb. per sq.ft.).

To convert pounds per square foot into kilograms per square meter, multiply by 4.883. Using 5 for a multiplier, gives a close approximation, as with

$$3 \textit{ lb. per sq.ft.} \times 5 = 15 \textit{ kg. per sq.m.}$$

(Instead of the exact 14.647).

Calories per kilogram can be converted into British thermal units per pound by multiplying by 1.8 or equally exactly by doubling the calories per kilogram, and then subtracting 10 per cent. of this amount. Thus,

$$8080 \textit{ calories per kg.} \times 2 = 16{,}160$$
$$16{,}160 \times 10 \textit{ per cent.} = 1616$$
$$16{,}160 - 1616 = 14{,}544 \textit{ B.t.u. per lb.}$$

The reverse calculation is not quite so simple, as the heat units per pound must be multiplied by 0.556 to obtain the calories per kilogram.

Thermometer Scales

The simplest method for converting Centigrade to Fahrenheit degrees is the following, but the writer does not claim originality in the fundamental principle on which it is based.

The two fixed standards by which thermometers are calibrated are, the freezing and boiling points of water. On the Fahrenheit scale they are 212 and 32 deg., respectively, and on the Centigrade scale 100 and 0 deg. Thus there are 180 divisions (or degrees) between these two critical temperatures on the Fahrenheit scale and only 100 on the Centigrade. Doubling Centigrade degrees to obtain Fahrenheit gives a product 10 per cent. too large so, multiplying by 2 and subtracting 10 per cent., gives again a simple method of conversion. Thus:

$$100 \times 2 = 200 - 20 = 180$$

Unfortunately, the Fahrenheit zero is 32 deg. below the freezing point, or the zero on the Centigrade scale, so 32 deg. must always be added to obtain degrees Fahrenheit, thus:

$$180 + 32 = 212 \textit{ deg.}$$

By memorizing a few more or less fixed points and their equivalents, the writer found he could sense the value of the Centigrade readings without attempting even this simple method of conversion.

0 deg. C. = 32 deg. F.—The freezing point of water
4 deg. C. = 39 deg. F.—Temperature of water at its greatest density
15 deg. C. = 60 deg. F.—(This should be 15.6 deg. C.) Average atmospheric temperature
38 deg. C. = 100 deg. F.
100 deg. C. = 212 deg. F.—The boiling point of water

The following tabie sums up in compact form, for easy reference, the various rules hereinbefore given:

Dimensions etc.	Unit Used	Converted to	Rule
Weight	Kilogram	Pounds	Multiply by 2 then add 10 per cent.
Lengths	Meter	Feet	Add 10 per cent. then multiply by 3
Surfaces	Square Meter	Square Feet	Add two 10 per cents, then multiply by 9
Volumes	Cubic Meter	Cubic Feet	Add three 10 per cents, then multiply by 27
Capacity	Liter	Quarts	Add one-half of 10 per cent. (or 5 per cent.)
Temperature	Centigrade	Fahrenheit	Multiply by 2; subtract 10 per cent, then add 32
Heat	Calories per Kilogram	B.t.u. per pound	Multiply by 2 then subtract 10 per cent.
Heat, B.t.u. per lb.	Calories per kilogram		Multiply by 0.556 (or divide by 6 and then by 3)
Pressures	Kilograms per square centimeter	Pounds per square inch	Multiply by 14.223 or divide by 0.07
Pressures	Pounds per square inch	Kilograms per square centimeter	Multiply by 0.07
Evaporation	Kilograms per square meter	Pounds per square foot	Divide by 5
Evaporation	Pounds per square foot	Kilograms per square meter	Multiply by 5
Distance	Kilometers	Miles	Multiply by 0.6 and add 5 per cent. of the product
Distance	Miles	Kilometers	Multiply by 1.6
Capacity	Cubic centimeters	Cubic inches	Divide by 16 (or by 4 twice)
Capacity	Cubic inches	Cubic centimeters	Multiply by 16

As most of the results obtained will be in error, to the extent already explained, where exact results are needed, one should refer to conversion tables, such as those in Kent's or Suplee's engineer's pocket books, Hering's "Conversion Tables," or to the work issued by the Hartford Steam Boiler Inspection & Insurance Co. on the metric system.

A table of prefixes and their values as used in the metric system, taken from Hering's "Conversion Tables," follows:

PREFIXES USED IN THE METRIC SYSTEM

Micro-	0.000 001	or 10^{-6}
Milli-	0.001	or 10^{-3}
Centi-	0.01	or 10^{-2}
Deci-	0.1	or 10^{-1}
Deca- or Deka-	10.	or 10^{1}
Hecto- or Hekto-	100.	or 10^{2}
Kilo-	1 000.	or 10^{3}
Myria-	10 000.	or 10^{4}
Mega-	1000 000.	or 10^{6}

Thus one millimeter equals 0.001 meter, or one kilometer equals 1000 meters.

Quitetite Reducing Valve

This reducing valve is manufactured in this country by the Auld Co., 1253 North 12th St., Philadelphia, Penn. The valve has been designed to give a positive closing control and to obviate any tendency of the reduced pressure to creep past the point at which it is set.

The controlling area of the valve is equal to six times the area of the back of the valve and the danger of an accumulation of pressure on the reduced pressure side is eliminated. The valve is designed to maintain a constant reduced pressure even with great fluctuation in the initial pressure.

Referring to Fig. 1, the high-pressure steam enters through the inlet and acts between the valve *D* and piston *F*, Fig. 2, which are of the same area and therefore in equilibrium on the high-pressure side. A reduction of the pressure is obtained by screwing up the adjusting nut *A*, Fig. 2, until the pointer *B* on the spring bolt is opposite the figure representing the reduced pressure required. Acting through the lever *C* the extension of the spring opens the valve *D*, Fig. 2, and passes steam at a reduced pressure to the outlet side. When the pressure of this reduced steam tends to rise above that required, it closes the valve by acting on the back of the valve *D* and chamber *E*. When the pressure tends to fall the tension of the spring overcomes the force holding the valve closed and opens the valve, allowing it to admit more steam to the low-pressure side; in this way the reduced pressure is kept constant.

A flexible-rubber composition diaphragm *G* is fitted at the lower end of the valve body which makes a frictionless steam-tight packing between the stationary and movable lower half of the valve. This diaphragm is protected from contact with steam by water of condensation, which

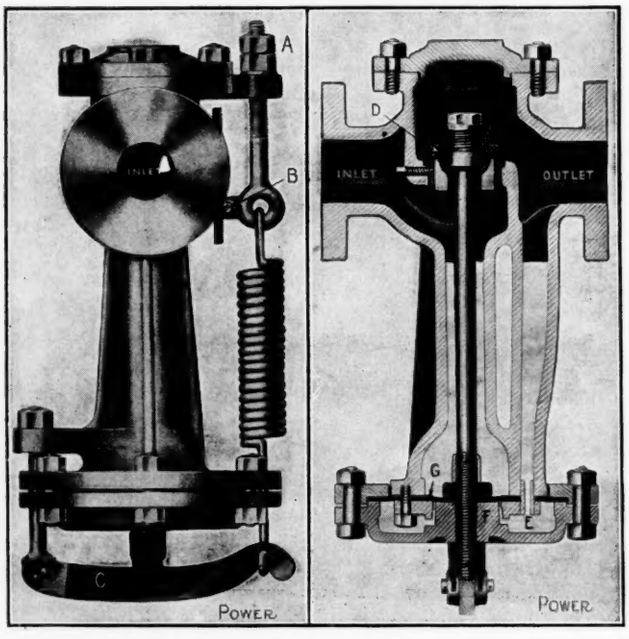


FIG. 1. SPRING AND LEVER

FIG. 2. SECTION THROUGH VALVE

collects in the lower part of the valve and keeps the diaphragm cool.

The valve is made in sizes from ½ in. upward with screwed or flange connections. The sizes above 2 in. have standard flanged ends. They are suitable for use wherever it is desired to reduce the steam from a higher to a lower pressure. The valve is designed to maintain a reduced pressure of from 2 to 3 lb., or other very low pressures on the outlet side, while the boiler pressure may be as high as 250 lb. per sq.in.

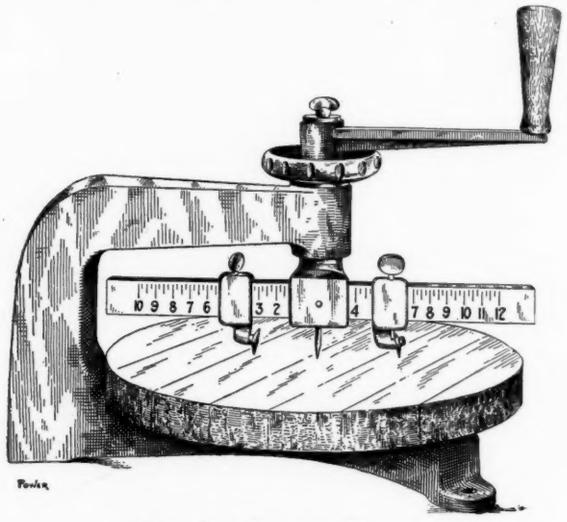
❖

Orders have been received in the Crewe Railway Works, England, for a large number of locomotives which will be the most powerful in that country. They are to be of great size, and are intended especially to draw very heavy loads at great speeds. The locomotives will be of the four-cylinder type, the cylinders all acting independently of one another. The distribution of steam will be by a new piston valve.

Stewart Gasket Cutter

The accompanying illustration shows a gasket cutter for cutting sheet asbestos, fiber cloth, wire insertion, copper, lead or other metallic packings to any size from 1½ in. up to 12 in. in diameter.

The frame is cast iron, and has a hard maple table secured to it by screws. The crank has a square opening which fits over the vertical spindle with a ½-in. space between the top of the spindle and the top of the crank, to allow for adjusting the thumb feed-regulating screw.



STEWART GASKET CUTTER

The force-feed handwheel may be used on soft packings for feeding the cutters downward. The carrier bar is graduated in inches, and any required size of gasket can be obtained by adjusting the cutters to the scale. The cutters are tool steel, and are dished on the inner side, concave on the outer and set at a slight angle.

In cutting fiber or other hard material the thumbscrew may be adjusted by a quarter turn so that the feed is automatically regulated. The carrier bar moves down ⅛ to ½ turn, to one revolution as desired.

This machine is made by L. R. Stewart, 70 East Thirty-first St., Chicago, Ill.

❖

The Salting of Mr. Fresh

BY R. O. RICHARDS

Swaggering into the presence of Podgers, the master mechanic, he said:

"My name is Fresh—Joe Fresh. I'm the guy that put poles on tadpoles, and I'm from the firm that smears butter on butterflies."

"You're from Butterfly & Co., the machinists?" queried Podgers.

"Yaas. Come to do surgery on your sick engine."

"Sit down, Mr. Fresh," said Podgers quietly, "and I'll state the symptoms. The engine is really not what you may call ill; I'd diagnose her case as plain laziness. She enjoys too many luxuries, and I want you to remove some of them. I want you to take away the pillow from her pillow block, the rocker from her rocker-arm, the bed from her bedplate, and the pipe from her exhaust. And I think she would work better if you removed the cap from her head, the jacket from her cylinder, the slippers from her crosshead, and clothe her in more workmanlike overalls and jumper. Also, you may remove the banjo from her governor, shoo the fly from the flywheel, take the dyn from the dynamo, and—"

But here Podgers saw that his visitor was beyond hearing—poor Mr. Fresh had collapsed.

ELECTRICAL DEPARTMENT

Drying Out Electrical Machinery

By Francis H. Davies

The circumstances under which a thorough drying out of electrical machinery becomes necessary are comparatively rare, but when the need does arise, it is generally urgent, and should be carried out in an expeditious and efficient manner. Considerable experience has been gained on this subject, and it is apparent from the results obtained after the Seine floods in Paris and upon other occasions, that most of the methods generally employed are good provided they are thoroughly carried out. Failure is generally attributed to the method, but more often it is due to insufficient time being allowed or to the neglect of certain precautions. Circumstances will materially affect the amount of damage done by immersion; that is, much will depend upon the quality of insulation, the dirtiness of the water and to some extent the time the machinery has been immersed.

It is important that when the water subsides or the machine has been lifted out of it, the process of drying be commenced without delay. If this be done the drying-out process will require much less time and there will be a better chance of success. If, on the other hand, the machine is left exposed to the air in a wet condition for a week or two, it has been found that in many cases no amount of drying will be effectual, owing to the insulation having been destroyed. Generally speaking, flood water is dirty, containing mud and decayed vegetable matter, and when to this is added the oil which is always present around machinery, and possibly the acid from neighboring accumulators, it is evident that a thorough washing is an essential preliminary. This should be carried out at once before the mud has had time to dry, and it can scarcely be overdone. If there has been much oil about and it is found to have worked into the windings, benzoline or gasoline will be found effective; and should there be signs of acid corrosion, a weak bath of potash followed by a thorough cleansing with pure water is a good treatment.

These preliminaries having been completed, attention must be at once turned to the application of heat for drying. There are many methods of doing this, the choice depending upon their relative convenience. Coke fires, open or closed, steam heat and the passing of current through the windings may be used singly or in conjunction. If the machinery is small it may be taken apart and baked in the ordinary drying oven. This is the better course to take with field coils of all sizes and small armatures, but the proposition is rather a different one to that for which a drying oven is ordinarily used as the coils will be excessively wet and may require higher temperatures and a longer time. Ovens of this sort are operated on two systems—by heat alone at a temperature of about 200 deg. F., or by heat and a partial vacuum which tends to draw out the moisture. In the second case the heat required is lower, the effect of a temperature of 200 deg. F. being about equal to 240 deg. where heat alone is used. In either case it may be necessary to extend the baking over several days, but it is impossible to speak definitely upon this point as circumstances vary so considerably and machines themselves are widely different in the effect that immersion produces.

Insulation tests should be made at intervals, and it will generally be found that while the insulation resistance rises fairly rapidly to thousands of ohms, progress is slower toward the end. When it is considered that the amount of water which has to be drawn out of a large machine after it is externally dry may amount to several gallons, it is clear that the operation may be lengthy.

If a machine is too large to take to the ovens it must be dried where it is and a certain amount of ingenuity is often necessary to devise satisfactory methods. The chief agents available are the coke fire (preferably inclosed), the steam radiator and electric current. The machine should be dismantled to some extent so as to allow the hot air to penetrate easily to all parts, and it has been found a good plan to rotate the armature at about its normal speed so as to throw out some of the water by centrifugal action. In doing this it is important to make sure that no potential is set up as the insulation might be broken down permanently. Hot air generated by a closed stove is preferable to the direct action of an open fire as the acid fumes of the latter are deleterious. To dry a machine in this way it should be entirely inclosed by a wooden structure, the joints of which are covered with stout paper to prevent leakage. The stove should also be inclosed with a flue pipe leading outside to the air, and if one or more small fans are placed in the right position, proper circulation (which is very helpful in drying) can be kept up. The same principal is applicable where steam radiators are used, but if timber is not handy an effective substitute will be found in a stout tarpaulin carefully arranged so as to prevent leakage. A temperature of about 180 deg. F. should be aimed at, and it may be necessary to maintain this for several days.

Electrical drying by means of a current generated in or passed through the windings is usually a longer operation, but at times it may be the only method available. It is seldom applicable at the start, because it may cause damage by electrolysis if not by actual breaking down of the insulation. Until the latter begins to test out at a fairly high value currents at low voltage must be used, and according to the nature of the machinery these will be attained in different ways. Armatures may be dried by being short-circuited at the brushes and run slowly with a weak field. As the insulation improves, both the field and the speed may be increased until the highest safe temperature is attained. The danger point is about 300 deg. F., at which heat cotton commences to discolor. The commutator often presents special difficulty and it may become necessary to take it off and dry in an oven. If the insulation remains low obstinately this is generally the place to look for the trouble. Should it be preferred to pass current through the machine from an external source the armature should be kept rotating slow-

ly as this will tend to more uniform drying, particularly of the commutator.

Transformers are difficult to dry out when thoroughly wetted, owing to the depth of their windings, and to assist matters it is well to remove any external insulating wrappings. A low voltage current should then be passed through the high potential coils, the low potential side being short-circuited.

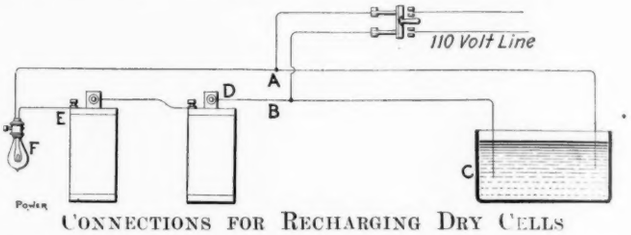
Generally speaking, electric plants do not suffer from excessive wetting to the extent that would be anticipated even if entirely submerged for weeks. Remarkable proof of this was found in the case of the Seine floods of Paris in 1910, where machines and cables which were then submerged for several weeks and apparently ruined are at work today. One particularly striking fact is that batteries of accumulators were quite uninjured by several hours' immersion, the higher specific gravity of the acid causing it to remain in the cells with very little dilution. There also does not appear to have been any damage by reason of the battery discharging through the water, as in one instance a battery which was covered for several hours by 10 ft. of water was found capable of giving a long discharge after the flood had subsided.

Modern underground cables if properly installed are fairly proof against damage by water. A good lead-covered impregnated paper-insulated cable if well jointed with water-tight boxes will suffer no harm, and should the water find its way in, it is usually only necessary to cut off a few yards at the end where the water will be found to have penetrated in between the core and its immediate insulation. Rubber cables unprovided with a lead sheath will not stand so well unless they are thoroughly waterproofed and quite new. The insulation of an old rubber cable is quickly destroyed by water and it cannot be repaired. Telephone underground cables of the dry-core or air-space paper-insulated type are very susceptible to water, and, while the sheath may protect them indefinitely, the slightest damp will quickly put them out of action. In an extreme case it is necessary to take off the lead sheath, dry the cores in an oven and then resheath the cable, but in the ordinary course the application of a desiccating machine to the dry end of the cable will suffice. This machine consists of a gasoline motor or hand-driven air compressor, air receiver and four cast-iron cylinders containing bags of calcium chloride, the whole being mounted on a truck so as to render it portable. A special connection is made to the cable, and air is pumped in at a pressure up to 30 lb. per sq.in. In passing from the compressor it flows through the calcium-chloride cylinders and emerges from them in a perfectly dry condition. It then flows along the cable through the air spaces between the wires, and emerging at the wet end carries with it the entrained moisture. The operation may take several hours or even days in a bad case.

Recharging Dry Batteries

No doubt many readers of POWER have had dry batteries which after a time have lost their strength and were thrown away as useless with the belief that they were beyond repair. Dry batteries will not only give out due to excessive use but also from standing idle upon the shelf when not in use. When batteries are not corroded badly at the connections or the zinc shell eaten away they can frequently be recharged and made to give service for some time.

The first thing to do when batteries have given out is to look at the connections which may have become broken or corroded. If the circuit seems to be all right an examination should be made of the cells to see if the zinc shells are sound and in good condition. If the cells are not eaten through, the batteries may be connected in a direct-current circuit as shown in the sketch, the lamp acting as a resistance. Having arranged the batteries and the lamp first allow the ends of the two wires *A* and *B* to be submerged in the jar *C* containing water in which a



CONNECTIONS FOR RECHARGING DRY CELLS

little salammoniac has been dissolved. It will be noticed that one wire will give off a greater number of bubbles than the other; this wire should be connected to the carbon terminal *D* of the batteries the other wire *A* to the lamp *F*. Having made the proper connections and removed the wires from the jar of water the current is allowed to pass through the cells for half an hour. It will be found helpful if a hole is melted through the wax of each cell and the latter submerged in water for a few minutes before the current is passed through it. When removing from the water the hole should be sealed by remelting the wax.

MARTIN MCGERRY.

Holley, N. Y.

Reversed Polarity

Mr. Gibbeney's inquiry in the Jan. 14 issue does not state what kind of load was being carried at the time, but I presume it was a motor load. Due to the sudden slowing down of the engine the motors failed to respond to the sudden change of speed. Had the engine slowed down gradually the motors would have responded and also slowed down, but due to the momentum of the shafting and machines which they were driving they were driven as generators feeding current back through the line and series winding to the generator. The shunt field had become so weak by that time it was neutralized and the polarity reversed.

That no trouble was noticed on speeding up the engine again except the reversal of the polarity was due to the current being so weak by that time in the release magnets of the starting boxes that they had let go and the starting arm had gone to the off position, thus opening the line between generator and motor. Had they not done so there would have been a short-circuit which would have blown the fuses on the motors, or blown the circuit-breakers.

It will be noticed on shutting down a direct-current motor that there is sometimes quite an interval of time after the main switch is pulled before the motor stops, due to the momentum of the shafting or machines which are being driven.

Also the arm on the starting box stays up against the release magnet until the motor is almost to a standstill, which shows that the motor is acting as a generator and continues as such until it fails to generate sufficient current to hold the starting arm in place when the spring on the arm throws it to the off position.

LEON L. POLLARD.

Fairfield, Maine.

In all probability Mr. Gibbeney has one or more motors on the line pulling machinery with heavy rotating parts. When the governor on the engine was unlatched the momentum of these parts kept their driving motors running long enough to generate enough current to reverse the polarity of the generator.

If he had raised the voltage and brought these motors up to speed with the polarity reversed, unlatched the governor again suddenly for a moment, tripped the machine circuit-breaker, and brought the engine back to speed, I think he would have found the polarity correct again.

EARL PAGETT.

Coffeyville, Kan.

The reversal of polarity was probably indirectly caused by a temporary short or overload, which unlatched the governor and in turn slowed down the engine.

In the meantime moderate to heavy currents were flowing through the armature circuit and a minimum current was passing through the shunt field by reason of the slower speed.

Hence the armature reaction neutralized and reversed the already weak field, and the latter in turn reacted on the slow-moving armature coils and created a reversed electromotive force which reached normal when the speed reached the ordinary limit.

BEN DAWSON.

Cedar Rapids, Iowa.

[Replies similar to those of Mr. Pollard and Mr. Pagett were received from William Hirst, Trenton, N. J.; J. W. Bend, Cincinnati, Ohio, and J. L. Birchell, of Baltimore, Md.—EDITOR.]

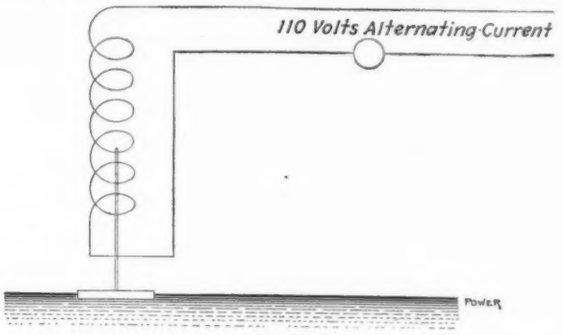
Water Level Indicator

Many different schemes are in use to indicate the height of water in tanks and reservoirs, most of which use contacts and a battery. The accompanying sketch, however, shows a scheme that uses neither of these features.

It is simply a reactance coil having a movable core, actuated by the float, the water level being gaged by the brightness of the lamp. I used an indicator of this kind to indicate the approximate height of the water in the forebay of a hydro-electric plant. Two 8-cp. lamps connected in parallel and placed side by side in a conspicuous position in the dynamo room were connected through 1800 ft. of No. 10 single copper wire to the reactance coil placed at the forebay up on the mountain side. The steel water pipe was used for the return circuit. The lamps burn brightly at low water and dim at high water and after a little experience the operator is able to judge very closely the intermediate points.

For those who might want to make such an indicator where the conditions are similar to the foregoing, I submit the following data:

The difference in water level to be indicated was 20 in. The coil was 20 in. long, made by winding 13 layers of No. 18 cotton-covered copper wire on a piece of fiber tube of 7/8 in. inside diameter; core of 5/8-in. solid soft



REACTANCE COIL IN CIRCUIT OF SIGNAL LIGHT

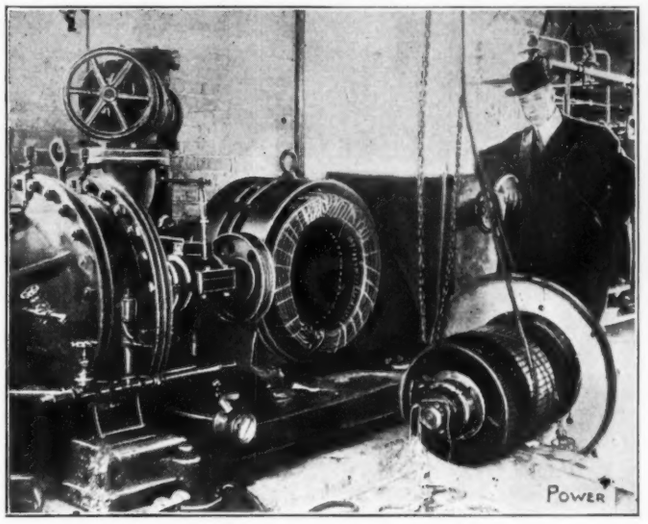
iron, 20 in. long or over. One 16 cp. or two 8 cp. lamps were connected in parallel and put in series with the coil. The supply was 110-volt alternating current.

F. J. STOREY.

Richmond, Calif.

Accident to Induction Motor

A 125-hp. two-stage motor-driven turbine pump was installed for fire purposes. It had been run only a couple of times for a few minutes on each occasion and, at the third trial, the operator heard a tearing noise and immediately shut off the power. Upon removing the end of the motor casing, it was found that some of the coils had dropped and came in contact with the fan blades, which had torn the insulation from several of them.



ARMATURE REMOVED AND FIELD COILS TIED IN PLACE

The armature was removed, the torn insulation retaped and the coils carefully tied up. The illustration shows the armature removed and the method used to tie up and support the coils.

JAMES E. NOBLE.

London Junction, Ont., Can.

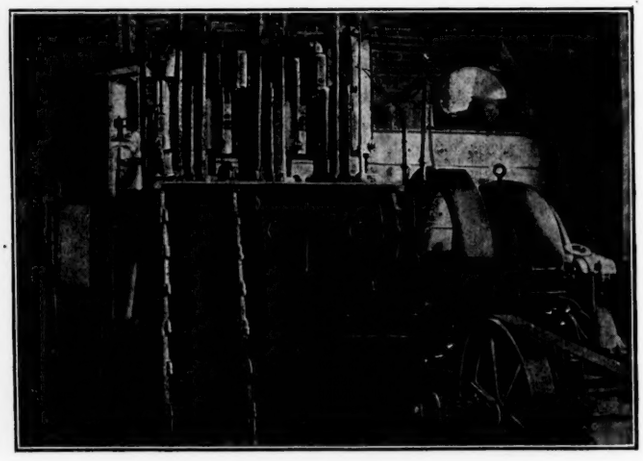
GAS POWER DEPARTMENT

Operating Costs of Small Gas Engine Plant

By M. W. Utz

The following operating data are taken from the records of the Municipal Electric Light Plant of Minster, Ohio. The plant consists of one 12x12-in. and one 11x12-in., three-cylinder vertical four-stroke-cycle gas engines direct connected respectively to 62.5- and 50-kw., 250-volt direct-current generators. Engine No. 1 is herewith shown.

Both engines have make-and-break ignition, current for engine No. 1 being supplied by a magneto bolted to the engine frame and driven by a friction pulley from the flywheel; engine No. 2 is supplied by a ¼-kw. generator belted to the engine shaft. Both are equipped with batteries for starting or for use in case of a breakdown of the magneto or generator.



One of the Main Units

Compressed air at 225 lb. pressure is used for starting, this being furnished by a 3x4-in. duplex compressor, belt-driven by a 2-hp. gas engine. Natural gas of about 900 B.t.u. per cu.ft. is used for fuel. The engines are lubricated by the splash system and use four gallons of oil per 24 hr., the oil costing 19c. per gal.

The first cost of the engines, generators, air compressor, tanks, switchboard, etc., was $9000. Engine No. 1 has been in service three years, running about 16 hr. per day, and engine No. 2 has been in service two years, running about 18 hr. per day. The repairs on these engines since their installation have been practically nothing and the service is good.

Owing to the fluctuations of the day load, and the ease of starting an engine, one engine is started and stopped quite frequently. An engine can be started, brought up to speed and cut in at the switchboard in parallel with the other in little over a minute.

Table No. 1 shows how the load varies during different periods for a typical daily run, and Table 2 gives the gas consumption and electrical output for the month of April, 1912. Table 3 gives figures on the cost of power for one month, is fairly accurate and also a good average for the year.

TABLE 1. TYPICAL DAILY LOAD

Time	Cu.ft of Gas Consumed per Hr.	Output in Kilowatt-hr.
12 M.		
1 a.m.	415	26
2	410	24
3	390	24
4	385	23
5	375	20
6	325	13
7	400	25
8	550	40
9	475	36
10	475	35
11	475	35
12 noon	400	26
1 p.m.	375	25
2	575	45
3	475	36
4	500	40
5	475	38
6	425	26
7	475	31
8	585	43
9	590	43
10	450	27
11	400	23
12	325	19
Total	10,725	723

Average gas consumed per kilowatt-hour = 14.8 cu.ft.
Oil consumed = 4 gal.

TABLE 2. GAS CONSUMPTION AND ELECTRICAL OUTPUT FOR ONE MONTH

Date	Cu.ft. of Gas Consumed	Output in Kilowatt-hours	Fuel cost per Kilowatt-hour, cents
April:			
1	9,500	560	0.0050
2	9,850	599	0.0049
3	10,200	635	0.0048
4	9,825	587	0.0050
5	9,725	566	0.0051
6	10,950	684	0.0048
7	6,350	369	0.0051
8	10,000	642	0.0046
9	9,850	625	0.0047
10	10,050	638	0.0047
11	9,875	653	0.0045
12	10,000	660	0.0045
13	10,650	682	0.0046
14	5,875	304	0.0058
15	10,125	665	0.0045
16	9,750	621	0.0047
17	10,950	724	0.0045
18	10,725	723	0.0044
19	10,325	677	0.0045
20	10,400	658	0.0047
21	5,550	287	0.0058
22	9,525	561	0.0050
23	9,375	578	0.0048
24	9,175	552	0.0049
25	8,975	536	0.0050
26	9,375	575	0.0048
27	9,775	615	0.0047
28	5,375	276	0.0058
29	10,900	705	0.0046
30	10,250	651	0.0047
Total	283,250	17,608	Average..0.0482

TABLE 3. TOTAL COSTS FOR MONTH

Fuel:	
283,250 cu.ft. of gas at 0.30 c. per 1000 cu.ft.	$84.97
Labor:	
2 engineers at $55 each	110.00
Oil:	
120 gal. at 0.19c. per gal.	22.80
Interest, depreciation, etc. 15 per cent. per annum on $9000	112.50
	$330.27

$$\text{Cost per kw.-hr.} = \frac{330.27}{17{,}608} = 1.87\text{c.}$$

The Paragon Engine

One of the difficulties met with in gas- and oil-engine practice is the high pressure and temperature of the exhaust gases, which not only carry off considerable heat, but also have to be passed through a silencer. Many attempts have been made to overcome this drawback by adopting the compounding principle as in steam engines and by other means, but hitherto none of these has attained any appreciable measure of success. W. P. Durtnall, however, the inventor of the "Paragon" system of electrical transmission of power for the propulsion of vehicles, ships and railway trains, has recently devised an entirely new method of solving the problem, which seems calculated to achieve the desired end without introducing complications into the design.

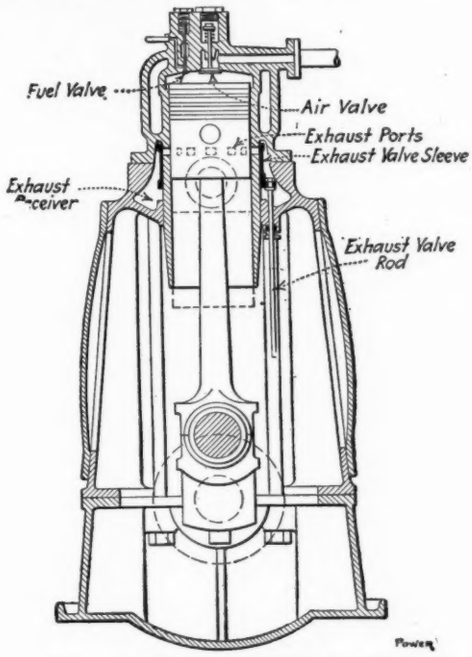


FIG. 1. SECTION THROUGH ENGINE

To put the matter briefly, Mr. Durtnall controls the exhaust valve in such a way that the travel of the piston during expansion of the charge is twice as long as its travel during compression. It is put into practice without in any way affecting the regularity of the stroke of the piston, which is always of the same length. The principle is applicable to both two-stroke-cycle and four-stroke-cycle Diesel, as well as gas engines.

Fig. 1 shows a section of a Diesel engine of the two-stroke-cycle type using the "Paragon" cycle. Besides the fuel valve there is a valve to admit air for scavenging, both in the cylinder cover, and the exhaust valve is a sleeve covering a ring of ports around the middle of the cylinder, and operated by a rod from the crankshaft. The cycle is as follows:

Starting with the piston at the top of the compression stroke, and the crank on the inner dead center, as shown, the air in the compression space is at a pressure of about 500 lb. per sq.in., and a temperature of about 1000 deg. F. As the crank passes the center, the fuel oil is sprayed into the compression space, and immediately ignites, continuing to burn and to maintain the pressure over a portion of the working stroke, as in the ordinary Diesel type. After the fuel is cut off, the gases expand until the piston reaches the end of its stroke, the exhaust ports being closed by the sleeve; at the end of the stroke the gases are almost at atmospheric pressure and a comparatively low temperature, and the exhaust valve now being opened, they escape almost noiselessly. The air scavenging valve is now opened, and a rush of air through the cylinder and out of the exhaust ports sweeps away the products of combustion, until the piston on the return stroke covers the exhaust ports and begins to compress the charge of pure air trapped in the cylinder. The rise of pressure closes the air admission valve, and at the end of the inward stroke the cycle is repeated.

It will be seen that the expansion stroke is twice as long as the compression part of the stroke. The indicator diagram obtained is shown in Fig. 2, the stroke being represented by the length *EC*. In an ordinary Diesel engine with this length of stroke, the compression space would correspond to *EH*, but in the Paragon engine the compression space is reduced to *EG*, and compression does not begin until the piston arrives at the point *D*. At *A* compression is complete, from *A* to *B* the fuel is burning, and from *B* to *C* expansion takes place, release occurring at *C*. The shaded area *F* represents the work of compression, the remainder of the diagram being a measure of the useful work done on the piston.

Fig. 3 shows the diagram of a Paragon engine working on the four-stroke cycle. In this case compressed air is not used for scavenging. On the suction stroke, from *A* to *B*, air is drawn into the cylinder; at *B* the induction valve is closed, and the pressure in the cylinder falls below atmospheric pressure, as shown by the line falling from *B* to *D*, the effect of the difference of pressures on the front and back of the piston being to check the motion of the piston and the parts attached to it, and on the return stroke to accelerate these parts, thus cushioning the stroke as in a steam engine, without appreciable loss of energy. At *B* on the return stroke compression commences, and at *E* it is complete; the fuel is then sprayed in, and burns during the working stroke up to the

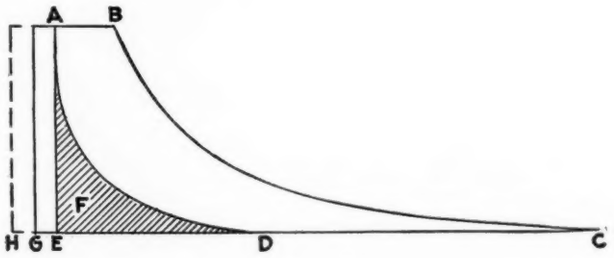


FIG. 2

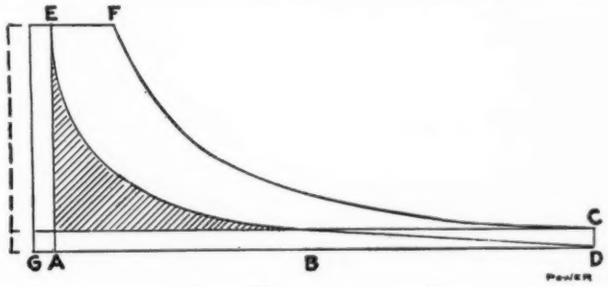


FIG. 3

point *F*, after which expansion proceeds to the end of the stroke at *C*. The exhaust valve is opened as the crank passes the center, and on the return stroke the piston sweeps out the burnt gases, the cycle being then repeated. Evidently the same effect is obtained as in the case of the two-stroke-cycle engine.

Owing to the reduced wall surface of the compression space, it is claimed that less heat is lost to the jacket, and the longer expansion permits a larger proportion of the energy to be abstracted from the gases, so that an increased thermal efficiency is obtained. The engine can also be worked on the Beau de Rochas cycle, in which the compression pressure is only about 80 lb., the engine being run with gas.

Pound in Engine Cylinder

Replying to Mr. Abel's inquiry, appearing in the Jan. 28 issue, it seems very probable that the pound is caused by too early ignition in one of the three cylinders. This condition could occur from anyone or a combination of causes, such as the crankpins not being spaced exactly 120 deg., the timing possibly not occurring at exactly 240 deg., or a combination of the two inaccuracies, both being added in the one cylinder.

The following is a much more probable solution:

A crankshaft so weak as not to be able to withstand the torsional strain at full power without presenting one crankpin out of its proper timing, might cause such a condition as described. The energy stored in the flywheel on the end of the crankshaft not coupled to the generator, might cause a lag in the crankpin motion at full load that would not show when the power is reduced by means of an over-rich mixture, or when the power demands are lessened by a partly closed throttle and later timed ignition.

A. E. Potter.

New York City.

Care of Dry Cells

The dry cell has many points in its favor as a source of ignition current for small gas and gasoline engines, especially those used for portable work, such as operating concrete mixers, sawing rigs for contractors' use and other similar work. A set of dry cells has the advantage over any other source of ignition current that the first cost is low, and as magnetos, and, in fact, all devices for supplying ignition current, are liable to injury or damage through exposure in the kind of work referred to, the loss is small, even if the battery is ruined through accident.

The dry cell, unless carefully protected, is liable to injury by rough handling and the jolting incident to the service for which it is used. The connections are likely to become loose, the hard wax seal broken or the cells short-circuited through carelessness in allowing tools to be thrown across them. The life of the dry cell is often materially shortened through drying out. It is also liable to be short-circuited through exposure to rain and snow.

With the idea of overcoming these difficulties a set of dry cells was placed in a box just large enough to accommodate them and deep enough so that the tops of the binding posts were about an inch below the top of the box, the connections made and the terminal wires led outside the box. The entire space around the batteries was then filled with melted paraffin up to a level with the top of the box. Paraffin shrinks in cooling, but with the space allowed between the tops of the binding posts and the top of the box all the cells and connections were completely covered with the wax when cold. The battery was then put in service on a portable outfit, where it was exposed to every change of temperature and humidity. During its life it passed through one severe rainstorm, being left outdoors unintentionally, a circumstance that would have ruined an unprotected set of batteries. The engine was used intermittently and for this class of service the battery lasted ten months, a very remarkable record.

The cost of fixing the batteries in this manner is very small. If a box just large enough is used, the cost of paraffin is small. In the foregoing, 4 lb. were used, costing 6c. per lb. In addition to the economy, the assurance that the batteries are always in good condition and ready for service is worth considerable.

James H. Beattie.

Washington, D. C.

Misleading Indicator Diagram

While running an economy test on a 5¾x12½ in. Otto gas engine using illuminating gas as fuel, an indicator diagram was obtained as shown. At first sight it seems an exceptionally good diagram with nothing irregular. If the cycle be gone over, however, it will be found that the suction line apparently lies above the atmospheric line. This represents an impossible condition, since the inlet gases were at atmospheric pressure, and they will flow only when the final pressure is lower than the initial.

Several diagrams similar to the one shown were obtained, indicating that the irregularity was not due to the shifting of the card on the drum. The trouble was then

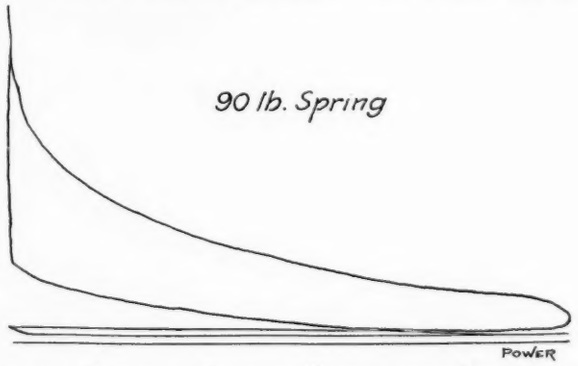


Diagram Showing Suction Line above Atmospheric Line

investigated, and was found to be in the indicator mechanism. There was lost motion due to a loose connection between the vertical link running up from the piston and the beam to which the pencil is attached. This allowed the pencil to remain above the atmospheric line whenever it was applied to the drum, the friction between the pencil and the paper preventing the beam from falling so as to trace the suction line.

L. Grossbaum.

New York City.

HEATING AND VENTILATION

Condensing Plants for Large Commercial Buildings

In an article in the Jan. 21 issue, Mr. Evans has advanced the proposition of applying the present-day practice of central stations to office-building isolated plants when the load exceeds 200 hp. This idea is in many respects excellent and is worthy of serious discussion. The problem, however, is hardly capable of any general solution and no general statements can be drawn up that will apply equally to all cases. In the final analysis each building must be taken as a separate problem and the most economical system can only be determined after a careful study of all the factors.

There is hardly a building in New York City that could compete with the Edison Co. were it not for the fact that during the six or seven months of the year when the lighting load is the heaviest, heat is necessary, and the amount of coal required is practically the same whether the electricity is generated or purchased. It is then only during the summer months that the cost of generating electricity is an important item and the saving during these months when the load is the lightest would not be in most cases suitable to warrant the expense of more economical engines and condenser equipment.

In presenting his side of the case, it would seem that Mr. Evans has avoided some of the disadvantages and also used figures that hardly agree with current practice. In a building over 10 stories high where forced hot water is used for heating and it is necessary to divide the system into independent units, there is the disadvantage of having the equipment in two parts of the building and a necessary loss of time in going from one to the other. Also the problem of making the steam line to the exhaust heater tight under 20 in. of vacuum becomes difficult. In a 20-story building with a heater on the tenth floor the steam connection would be some 150 ft. long with several fittings and couplings.

The statement that all large buildings have more or less undesirable space in the basement is hardly true. From the tight sqeezes in many office-building power plants it would seem that just the reverse is the case. In figuring the cost per year for mechanical service with and without isolated plants, the extra space required by the engines, generators and switchboard is usually charged against the plant. In this case the value of the floor space required by a cooling tower should be charged against the saving effected by its use.

The figure of 21 lb. of steam per kilowatt-hour at the switchboard for a condensing engine is hardly a fair one as a compound Corliss engine working under ideal conditions would be necessary to obtain this water rate. This type of engine is rarely used in office-building work.

The difference in the water rate of steam engines running condensing and noncondensing is about 20 per cent., and the amount of steam required for the condensing apparatus will average 7 per cent. of the steam used by the engine so that a condensing plant is much nearer to 13 than 25 per cent. more efficient than a noncondensing plant. With hot-water heating the point that just enough heat can be furnished to provide for the outside temperature and that overheating of the rooms and the wasting of heat to the atmosphere through open windows is eliminated, is well taken. It is a well known fact that in large office buildings heated by steam the radiators are very rarely touched, the temperature of the room being regulated by opening one or more of the windows.

In most buildings in New York City it is the author's opinion that the results would not favor a system such as suggested by Mr. Evans, yet the idea is of enough value to be considered as a probable method. In some localities, such as San Francisco, where the heating load is much less than the light and power loads, it would probably be the most economical system and might be the deciding factor in favor of a plant when other systems would not justify it.

W. L. DURAND.

Brooklyn, N. Y.

In the following, an attempt will be made to answer in order the points in Mr. Durand's discussion as to the feasibility, from a commercial standpoint, of the arrangement of the plant proposed in the Jan. 21 issue.

It is conceded that each particular plant would have to be analyzed before a decision could be made on the type of equipment to be installed, precisely as at present. The discussion mentions the comparatively slight variation in heat consumption of steam systems, for varying outside weather conditions, and the wastefulness due to open windows when rooms become overheated. The familiarity of engineers with the physical action of steam-heating plants causes a lack of appreciation of the advantages of the wide range of temperature and heat requirements of a hot-water system under forced circulation, and the bearing of this feature on the method of operation proposed. There are very few commercial buildings of any size where the power load, a large portion of the time, does not provide steam greatly in excess of the heating requirements. A glance at the exhaust heads in lower New York any winter afternoon will show the fallacy of Mr. Durand's statement that the amount of coal required would be nearly the same whether the electricity were generated, and exhaust used for heating, or purchased and the heating operated by live steam.

Under the conditions named, a portion of the power load may be operated to furnish steam under reduced vacuum for heating, and the balance may be operated under the maximum vacuum on a separate machine. The condenser would have to take care only of the surplus power load plus about 5 per cent. of that required for heating. The full condensing effect of the heating system is obtained at practically no expense.

Where automatic heat control is provided, a steam system utilizes nearly the same quantity of heat as a

water system; but the pressure and temperature of the exhaust steam, which affects the engine economy, is the same at all times or a little worse in mild weather. Where the power load is not much over 200 hp., it would probably not pay to install a cooling tower of large size. Vacuum could be carried in connection with the hot-water system in winter, according to outside weather conditions and the exhaust steam wasted to atmosphere in summer, as it is at present. In this case, the cooling tower or condenser would be very small and all of the condensing effect produced by the heating system. A fan system for ventilation, operated in connection with the water system, would answer the same purpose.

The fact that the water system uses just the amount of steam required at comparatively low temperature in average weather, makes condensing profitable. It would be practically impossible with a vacuum steam system.

TABLE 1. STEAM RATES OF 500-KW. TURBINE AT DIFFERENT VACUUMS AND HEATING REQUIREMENTS

Outside Temp., Deg. F.	Per cent. of Total Day Heating, Taken by Each Period (1545 hr.)	Av. Temp. Heating Water, Deg. F.	Vacuum to Produce Water Temp., In.	Steam Rate per Kw.-hr. (500 kw. Unit)	Steam Rate in Per Cent. of Atmospheric Rate	Steam for Heating in Per Cent. of 0 to 10-Deg. Period
0-10	0.6	200	0	43	100	100
10-20	3.25	190	6.4	39	90	90
20-30	13.25	177	11.5	35	80	79
30-40	32.4	163	17	31.4	73	70
40-50	22.6	143	22	27.3	63.5	56.4
50-60	27.8	115	26	23	53.5	46.2

Table I gives the exact operating conditions of a turbine plant and hot-water heating system, with average temperature of the water, amount of vacuum to produce the water temperature and steam consumption of the turbines without auxiliaries. The amount of steam required in the 0- to 10-deg. period is taken as 100 per cent. The percentages of time are those during the day taken from the Weather Bureau reports. It may be noticed that the range in percentages of the turbine for a constant load vary almost exactly with the heating requirements. This is not true with the reciprocating engine. The figures show that a constant load could be carried throughout the winter on a turbine; and, by varying the vacuum, the exact amount of steam in temperature and quantity will be provided for the heating system for all outside weather conditions. The rates given are for a 500-kw. Westinghouse-Parsons turbine. The table shows that 17 in. of vacuum, and above, can be carried over 80 per cent. of the heating season, for the power steam used on the heating system, with practically the same amount of radiation and the same temperature conditions in zero weather as would be required by a vacuum steam system. As the heating system would be operated in any case, this condensing effect could be obtained for practically nothing. Mr. Durand's statement that vacuum could be carried only in the summer, is erroneous to this extent. The table shows that for only about 15 per cent. of the time would the economy of the condensing machine be seriously interfered with.

In a vacuum steam system, the various vacuum pumps would require from 100 to 150 lb. of steam per horsepower-hour; while the water system would require more power at a much lower steam rate.

In comparing the reciprocating engine with the turbine, the friction load of the former is seldom taken into account as the engine is rated on indicated horsepower and the turbine on brake horsepower. The friction load of a turbine is small compared with that of a compound engine, as the turbine, due to the high speed, must be thoroughly balanced.

Table 2 compares a 500-kw. compound-condensing engine and a 500-kw. turbine under different loads at atmospheric pressure and 26 in. of vacuum, with saturated steam at 150 lb. gage pressure. The friction load of the engine is assumed for all loads at 12½ per cent. of full load rating or practically 80 hp. At full load and one-quarter overload, the turbine has a somewhat greater steam consumption than the reciprocating engine at 26 in. of vacuum, but at one-half load its steam rate is less. The comparatively small size of the turbine and generators, due to the higher speed, reduces the initial cost over an engine unit, and the space occupied will be about one-quarter, an important item in Mr. Durand's discussion. The oil question and separating apparatus would be eliminated on the turbine equipment and the foundation is another item in favor of the turbine.

In most reciprocating plants, several sizes of unit are provided on account of the poor economy of the reciprocating engine under one-half load. This is aggravated by clearance and cylinder condensation, which do not appear in the indicator diagrams. The turbine rate varies only ½ lb. between 50 per cent. load and 25 per cent. overload operated under vacuum, while the reciprocating engine shows an increase of 40 per cent. at one-half load. This means that with the turbine the number of units can be reduced without materially affecting the economy of installation.

When the turbine is operated on the heating system under partial vacuum, no adjustments are necessary; while with the compound engine the cutoff must be varied with the vacuum, and possibly the load, and the receiver pressure changed. The author has personal knowledge of a turbine plant operated with two machines for the last five or six years, under a 24-hr. load, ranging from 250 to 650 kw., with two peaks. Space had been provided for two additional units, but these have never been installed.

There is no question about the poor economy of a turbine when operated without vacuum, but where the vacuum is reduced in zero weather to provide steam for heating there is little difference in its economy and that of the reciprocating engine, as live steam would have to be added in the case of the latter.

Mr. Durand's assumption that the cooling tower could only be used during the summer months is caused by the known excessive heat requirements of steam-heating systems in moderate weather. In zero weather there would be practically no difference in economy between the non-condensing steam-heating system and the hot-water system; but, according to weather reports for New York and vicinity, the temperature is below 20 deg. only about 15 per cent. of the time and, during the present winter, there have been very few hours below 32 deg. during the daytime.

San Francisco is mentioned as a favorable place for the type of system proposed, on account of the mild climate. As the amount of vacuum is determined by the temperature of the circulated water and the amount of radiation, regardless of the latitude, it would probably be better economy to use less radiation and operate on only a slightly lower temperature of water than in New York, thus keeping the cost of the heating system low.

As far as the night load is concerned, the power seldom, if ever, furnishes sufficient steam for heating and a discussion of this period will be eliminated.

Regarding the placing of the hot-water pumps on an upper story, as the circulating pumps would be motor-driven, they would require less attention than the motors for overhead traction elevators. Attention is admitted and required; but, in connection with fan motors and traction elevator equipment in various parts of a high building, it would not be a serious matter. The valves for regulating the steam to the system on the upper level would all be in the basement or engine room, together with all thermometers and gages. This arrangement does not contemplate the regulation of the heat by varying the speed of the pump. The difficulty of making the exhaust pipes tight is admitted; but there would be only about four fittings and straight lengths of pipe and, perhaps, two valves. With the condensing equipment to assist, and an average vacuum of about 20 in., it is not insurmountable. When carrying full vacuum in summer or winter, this line would be cut out entirely.

The use of turbines over compound Corliss engines would give more than space sufficient for a cooling tower in a less desirable location from a rental standpoint. For a 1000-kw. unit, using 20,000 lb. of steam per hr., two spaces 12 ft. in diameter and head room of 18 ft. would be sufficient for the cooling towers.

The 21-lb. rate per kw.-hr. referred to was for a turbine without auxiliaries and was operated on a heating system, the condenser only keeping the circulating water from becoming overheated and regulating the temperature and vacuum.

It has been the writer's observation that few plants dare to load the units up to full load on account of someone outside suddenly throwing on sufficient additional load to overload the generators. This varies in different places. In office buildings, the engineer has greater control of the load, but in large loft buildings, furnishing power to tenants, the load is out of the engineer's control to a great extent. Under these conditions, the turbine would show some advantages.

Regarding the criticism of the high percentage of difference in operating cost between condensing and noncondensing conditions, the quantity was intended to apply to a comparison of the use of simple, high- or medium-speed engines, as generally operated against slight back pressure in installations of this class, with the possibility of condensing operation in connection with the hot-water heating system. Mr. Durand admits that compound engines are infrequently installed in this class of work and the comparison given shows that the author was not far off in his general assumption.

The following data regarding a plant about to be installed in a 32-story office building, now in course of erection in New York City, is submitted. Four 400-kw. compound Corliss units and one 200-kw. unit have actually been purchased. There will be 100,000 sq.ft. of heating surface, 32 elevators will be installed and these, with what miscellaneous power will be required in such a building, will aggregate about 500 kw., a load which would just balance the heating with steam or water in zero weather.

With a turbine, the heating system would produce 20 in. of vacuum on the average load of 500 kw. 80 per cent. of the heating season, the cooling tower taking about 10 per cent., or 50 kw. The cooling tower would have been designed to take care of 1000 kw., which would be ample to produce 26 to 28 in. of vacuum for the average summer load. The lighting load will be at least 400 kw. for 1000 hr. in winter, and this could have been operated entirely on full vacuum, so the cooling tower would have considerable more than the summer load to help pay for interest and depreciation. The reduction in boiler power, when running condensing, and the lower cost of turbine units over reciprocating engines, would have been nearly sufficient to pay for the cooling tower and condensing equipment.

The entire cost of power and heating equipment on the hot-water condensing basis would have been some $50,000 less than for the vacuum steam system with automatic heat control and the Corliss engine outfit, and at least 20 per cent. saving in fuel and water could have been effected.

In estimating the steam consumption of the engine, the author perhaps erred on the low side; but if he had placed it at what he actually thought it to be in practice, some other person might have claimed that it was too high.

The writer submits the following figures, which he considers fair, as the average difference between condensing at 26-in. vacuum and running noncondensing with a compound engine operating on saturated steam at 150 lb. gage. The difference between this outfit and a simple engine would, of course, be greater. In Table 2 a rate of 16 lb. per b.hp.-hr. is given for a 26-in. vacuum, and 21.1 lb. when operating against atmospheric pressure. This shows

TABLE 2. STEAM RATES FOR 650-HP. COMPOUND ENGINE AND TURBINE

Per cent. load	Hp.	Rate per I. Hp.	Total lb. Steam	Net Hp.	Rate per Net Hp.	Turbine B.hp. Rate
		26 in. vacuum, sat. steam, 150 lb. gage				
125	812	14.5	11,774	732	16.1	18.5
100	650	14	9,100	570	16	18.5
75	488	15	7,320	408	18	18.0
50	325	17	5,525	245	22.5	18.5
		Atmospheric exhaust, 150 lb. gage				
125	812	20.3	16,484	732	22.52	29.4
100	650	18.5	12,025	570	21.1	28
75	488	20.0	9,760	408	24.0	30
50	325	24.5	7,962	245	32.5	34

Engine friction on all loads = 80 hp.

$$\frac{5.1}{16} = 0.319 = 32 \textit{ per cent. increase}$$

$$\frac{5.1}{21} = 0.241 = 24 \textit{ per cent. decrease}$$

gross in steam consumption between condensing and noncondensing.

When comparing condensing and noncondensing operation, a correction is necessary for the difference in the temperature of the feed water. When running noncondensing, the feed water is at a temperature of 200 or 210 deg. and about 100 deg. for 26 in. of vacuum. The auxiliary steam necessary to raise the water 100 deg. would be

$$16 \times 100 = 1600$$

$$\frac{1600}{1000} = 1.6 \textit{ lb.}$$

steam per hp.-hr., making the actual rate condensing 17.6 lb. instead of 16 per hp.-hr. The injection water will have to be pumped against 75-ft. head, including the height of the tower and friction of the piping. If the building is not too high, the tower may be placed on the roof without fans. The static head on the pumps

and apparatus will determine this factor; otherwise, it will have to go in the basement or sub-basement. In the case referred to, a flue 10 ft. square and 450 ft. high could have been arranged, which would have furnished 100,000 cu.ft. of air per min. under about 2 in. of water pressure.

Assume that the cooling tower will cool the water 25 deg. and that the surface condenser is large enough so that with a 20-deg. rise all steam will be condensed. The latent heat at 26 in. of vacuum is 1026. Then,

$$16 \times 1026 = 16{,}416 \textit{ B.t.u. per b.hp.}$$

$$\frac{16{,}416}{20 \times 60} = 13.68 \textit{ lb. water per min.}$$

Circulating this against 75-ft. head would require

$$13.68 \times 75 = 1026 \textit{ ft.-lb. per min.}$$

If the hotwell and air pumps each handle 16 lb. of water per horsepower of the main unit per hour against a head of 75 ft., it will require

$$16 \times 75 \times 2 = 2400 \textit{ ft.-lb. per hr., or } 40 \textit{ per min.}$$

$$1026 + 40 = 1066 \textit{ ft.-lb.}$$

$$\frac{1066}{33{,}000} = 0.0323 \textit{ hp.}$$

With 50 per cent. efficiency, 0.0646 hp. would be required. Adding 25 per cent. for electrically driven pumps, would give 0.08 hp., or $0.08 \times 16 = 1.28$ lb. per b.hp.-hr. of the main unit. This is less than the 1.6 lb. required for feed purposes, so that steam-driven machines may be used without loss of economy up to the limit and the exhaust used for feed purposes. Correcting the steam rate, gives 17.6 lb. for 26 in. of vacuum and 21.1 lb. noncondensing. Then

$$\frac{3.5}{17.6} = 20 \textit{ per cent.}$$

net for the increase in steam consumption when changing from condensing to noncondensing, and

$$\frac{3.5}{21.1} = 16.6 \textit{ per cent.}$$

for the saving net of condensing over noncondensing conditions. Where a fan arrangement is required for the cooling tower, the figures would, undoubtedly, approximate those of Mr. Durand's, but in most cases, it is the belief of the author that fans can be avoided.

It should be remembered that this is true only for full-load conditions. If the water rate condensing for all loads were averaged, the percentage of difference would be as follows: From Table 2 the average condensing rate is

$$18.15 + 1.81 = 19.96 \textit{ lb.} = 20 \textit{ lb.}$$

The average noncondensing rate is 25 lb.

Then the percentage increase is $5 \div 20 = 25$ per cent., and the percentage decrease, $5 \div 25 = 20$ per cent.

The water saving through the use of a cooling tower would be about 3 lb. per hp.-hr. on all steam that ordinarily escapes to the atmosphere winter and summer, as plants are operated at present, at $1 per 1000 cu.ft.

It is admitted that the turbine is not as economical as the steam engine at full load, but with the less number of different-sized units, space occupied and the other items enumerated, it should have careful consideration. It is, of course, out of the question with vacuum steam systems.

The author would appreciate a further expression of opinion from Mr. Durand on the above discussion, or other readers of POWER interested along these lines, as improvement can only be made by intelligent suggestion and criticism.

IRA N. EVANS.

New York City.

Water Leaves Boiler

In answer to Luther Walling's inquiry in POWER of Jan. 21 regarding backing up of water in risers of the one-pipe steam-heating systems, would say that the risers in the wing are overloaded beyond their capacity. The size of returns given by Mr. Walling are too small. Good American practice is to provide returns having one-quarter of the area of the steam line. In this case for the 3½-in. steam line a 2-in. return should be provided, and for the 3-in. steam line a 1½-in. return. There is also a way to relieve overloaded risers. If each riser is connected to an overhead equalizing pipe, the greatest pressure in the nearest riser will expand toward the farthest riser and prevent excessive pressure drop. If Mr. Walling will use an overhead equalizing pipe and put in extra return lines to meet the difference in area he will have no further trouble.

New York City. C. W. ROOS.

I think the return ends of the circuits have been reduced too small. They should have been at least 2 in. in diameter to give good satisfaction on a single-pipe job. However, if a swing-check valve be placed between the return line and boiler, with a valve on each side to allow for inspection and repair of the valve, this will keep the water from backing out of the boilers. When a sufficient head of water from condensation is obtained, the circulation will be all right. I would also recommend the placing of a tee, with the side opening looking down, in the supply header. From the bottom of the tee drop a 1½-in. line into the return. This will keep the header dry and take care of any priming of the boiler. If the pipe work is properly arranged, the above repairs made, and a pressure of 3 to 5 lb. is carried in the boiler, there should be no more trouble.

Moorhead, Minn. J. H. NORTON.

The water leaves the boiler because the supply and return are connected too close together at the boiler. In other words, if the supply connection is near the front of the boiler, the return should enter the rear end. I would suggest running all returns into one large pipe and let it enter the center boiler opposite from the supply.

Bellefontaine, Ohio. W. T. HURD.

Mr. Walling should close the main steam valves on the boilers and build up the steam pressure to the blowing-off point. Then open the main steam valves on the boilers slowly and have the air cocks open on the return pipes in the basement so that the temperature of the return may be determined. When the water becomes hot, indicating that the supply and return pipes have become equalized, the air cocks may be closed and the return valves opened slowly. If they are opened before the steam and return pipes are equalized, water will rush out of the boilers.

Warm Springs, Mont. EDWARD N. JOHNSON.

EDITORIALS

Are Your Boilers Properly Inspected?

A steam-power plant represents a cash investment from which no direct profits are derived. From the day it is started it begins to deteriorate, parts begin to wear and the metal in the boiler is subjected to the action of furnace temperature, gases and to feed-water impurities.

When a boiler is given proper care and when operating conditions are of the best, it may be in good condition after twenty years or more of operation. On the other hand, if the boiler is abused, left to operate without proper care, it may become unsafe within a few months.

There are three kinds of men in charge of boilers: those who are careful and know their business; those who are careful, but not so well informed, and those who are both careless and ignorant regarding boiler operation.

A boiler in charge of a man of the first class would be in safe hands and would, undoubtedly, be found in good condition. With the second sort of attendant, it would be difficult to hazard a guess as to the condition of the boiler. If the engineer did not know where to look for defects, the boiler might be in a dangerous condition, no matter how careful he might be about maintaining the water level at the proper height and in keeping the boiler clean of scale.

When the man in charge of the boiler is both ignorant and careless, the chances are that the boiler is not cared for and defects are allowed to exist which, even if not of a dangerous character at the time, would soon become so.

In the large well kept plant, the chief engineer does not have the time nor is it his duty to inspect boilers. Therefore, this work is left to a subordinate who may or may not be competent to do the work.

But who is to determine whether the boilers in charge of the two least responsible classes of men are safe to operate or not? What protection have those employed about the plant, in the mill, factory or passers-by against a deadly explosion? How can these persons be safeguarded in states and cities where the boilers are not under the supervision of the state or city boiler inspectors?

Remarkable as it may seem, a steam boiler can be insured in any reliable boiler-insurance and inspection company for, approximately, twelve dollars a year. Such an insurance means that trained experts in their line visit the plant, making one internal inspection and at least one external inspection, two if it is possible to do so, each year. These inspectors work under the direction of mechanical engineers who are authorities on the proper construction and safe operation of steam boilers and their appurtenances.

What is the result? Any defect that can be detected is located. The inspector is competent to determine what repairs are necessary.

An engineer may detect a defect, but rather than shut down the plant will permit the defect to remain until some convenient time for making the repairs. The inspector has no scruples. If the boiler requires repair, it must be attended to at once or the risk is canceled. Consequently, the boiler is kept in a proper and safe condition.

One has but to read the reports of steam-boiler inspection companies to ascertain how many boilers are found operating in a defective condition, many of which are dangerous. How many dangerously defective boilers are being operated which are not under the scrutiny of either state, city or company inspectors is a matter of conjecture. When based on the number of defective boilers inspected, they must number among the thousands.

Life is uncertain at best and it is foolish to invite danger by neglecting to have boilers properly inspected, and even more so when the cost is but twelve dollars a year and a little inconvenience.

Perpetual Motion Fallacy

About every so often, here, there or somewhere, another springs up who is confident he has discovered the secret of perpetual motion. As a matter of fact, there is no secret about it; those who have studied science at all very soon discover there is no such thing in nature as getting "something for nothing." Energy does not spring from nowhere and the law of its conservation has not been violated since the world began. Energy can be variously transformed and converted, but none will ever be found anywhere that it was not some time or other put in. It may have been centuries ago, as the heat energy latent in coal, or it may have been but a moment before, as the lifting of a weight and putting it on a table, where, by virtue of its position and the work done upon it in lifting it against gravity, it possesses a certain amount of potential energy.

The effort to discover perpetual motion seems to be something that is bound to come into the life of most mechanically inclined persons sooner or later. It is very like the measles, most of us have to have it and it is better if we have it early in life. It takes harder if we don't get it until maturer years and recovery is slower. Many youngsters, handy with tools and having a natural bent for making things, have, consciously or unconsciously, worked on this problem of trying to get a machine that would give out energy continually once it is started, without ever having any more put in. This is amusing to them and their elders; does them no harm and keeps them out of mischief for a time at least.

On the contrary, it is one of the most pitiful spectacles of life to see a full-grown, able-bodied man obsessed with the idea that he has a perpetual-motion scheme that will really work. Seldom can those better informed convince him of the impossibility of the plan. Everyone who seeks to discourage him is considered either a jealous enemy or a misguided friend. When such a person really gets over his mistake, it is an occasion for rejoicing. Many wreck their lives or their minds before they get through.

Someone has written a book containing a classification and description of all the fundamental perpetual-motion schemes and it is a splendid antidote. We commend it to all who are laboring under such hallucinations. Most of them will find their own pet schemes already catalogued in this mechanical rogues' gallery. This work should be a warning signal on the shoals and keep some from embarking on the fruitless search for the impossible.

Small Factory Power Plants

Engineers of small factory plants are usually required to find and correct troubles in the factory equipment that, in larger establishments, are cared for by a master mechanic, superintendent or foreman steam-fitter.

The chief difficulty confronting the engineer in such plants is that of reducing wastes due to thermal losses and friction. In this direction, the engineer does not always receive the support of the management or the necessary appropriations to enable him to accomplish good results. As preposterous as it may seem, it is the experience of engineers that in factories where these and other kinds of losses are enormous compared to the size of the plant, it is hardest to get the means whereby to check, even appreciably, the wastes.

Hydraulic presses containing steam plates, steam-heated rolls for drying or mixing, vulcanizers, steam tables, drying rooms, etc., are part of the equipment common in many such factories. These apparatus need skillful attention to prevent them from becoming a source of serious waste. Naturally, an engineer wants to provide such equipment with good thermometers, correct gages, steam traps and, above all, the wherewithall to return to the boilers the condensate, which is a large part of the total water evaporated in the boilers.

There are altogether too many plants of this kind where the engineer gets a half-hearted, unwilling cooperation from the management.

The engineer has been given a bitter lesson. He resolves never to go ahead, of his own volition, to improve his next plant unless the management gives him very good reasons to believe that his services will be justly appreciated. Like begets like, and appreciation of a man's good service is the best inducement for him to give all of the best that is in him.

Operating Costs

Attention is called to the figures given by M. W. Utz, on page 224, upon the cost of producing power in a small municipal plant.

Such data are of particular value for two reasons: First, they afford engineers operating similar plants a means for comparison with the performance of their own plants; second, they show that the small gas engine, when installed and operated under the proper conditions, can compete very successfully with large steam plants as regards total cost.

In this particular case, the cost is less than two cents per kilowatt-hour, fixed charges included. Of course, the labor and oil items are low, but these are offset by a rather low load factor.

It would be desirable if more engineers of small plants would submit their cost figures as Mr. Utz has done. While space would not permit publishing many; still, if enough contributions of this character were received, the data could be compiled and, if published in tabular form, would be invaluable to engineers of such plants.

Simple Metric Conversions

Our allegiance to the English system of weights and measures, like our religion and politics, is largely a matter of our bringing up. With all their faults we cling to the old "inch" and "pound" and most of us hope it will be left to a later generation to put them in the discard. This is through no special affection for them on our part for it is generally granted that the metric units are superior; the principal obstruction to their substitution is our dread of the upset and confusion during the transition.

Meanwhile some of us occasionally have to deal with both systems and drag out our handbooks with their conversion tables to search out the relationship.

Albert A. Cary has done a real service to engineers in developing the simple methods for approximate conversions presented on page 217. They make possible mental calculations of the English equivalents of the foreign units sufficiently close so that one can get a quick appreciation of their values by comparison with familiar standards. This article deserves to be preserved or the essentials of its rules memorized. The latter would go a long way toward removing our dread of the metric system invasion.

Self Instruction in Engineering Mathematics

Every ambitious engineer who, because of the ironies of life, was unable to obtain a knowledge of mathematics in his early years, knows that the lack of a thorough understanding of the essentials of this subject is the chief reason that he never advanced to a position of greater responsibility and one for which the remuneration is greater than that of the ordinary engineer's job.

It is all very well for arm-chair theorists who were fortunate enough to be born of parents who could afford to pay for their educational training, to say that "any man who will set himself to the task can accomplish it." This assertion applies well enough to the young man of today but it never applied to men who are getting past middle age and who, despite an honest effort in their early years, failed to acquire a self-education in mathematics. There was nothing available at the time to enable them to get a working knowledge of this subject.

It is only of late that books have been available from which a man of ordinary intelligence could learn the essentials of the higher mathematics, particularly as it relates to engineering. The average mathematician does not seem to know how to write such a book; in fact, some books written for self-instruction give one the impression that the authors were afraid the readers would really learn something from them.

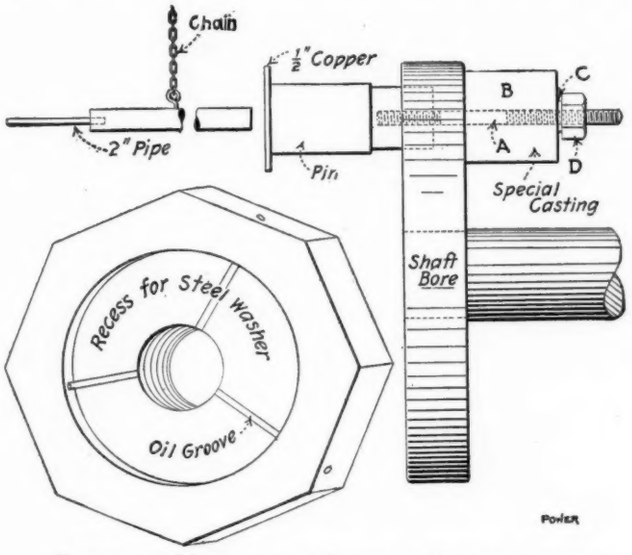
Happily, the young man who feels the need of a knowledge of mathematics can now get instructions from books that really instruct. The manner in which such books and our Study Course are received is evidence that they both fill a long-felt need.

READERS WITH SOMETHING TO SAY

Putting Crankpin in 5000-Horsepower Engine

A crankpin on the low-pressure side of a 5000-hp. cross-compound engine became so loose it had to be taken out and another pin put in. The dimensions of the new pin, which was made in the shop of the engine company, are as follows: Diameter, 14½ in.; length of bearing surface, 14 in.; thickness of crank disk, 11 in.; bore in disk, 12⅞ in., with a taper of 0.052 in. in 11 in. The weight of the pin was 1060 lb. and was left about $\frac{1}{32}$ in. large at the disk end.

The crank disk was a steel forging and it was planned to shrink the pin into the disk. The allowance for shrinkage was 0.007 in. Gasoline torches were used to heat the



SHOWING MANNER OF PUTTING CRANKPIN IN 5000-HP. ENGINE

disk, but after trying for twelve hours with no apparent success, this means of getting the pin in was given up.

It was then decided to pull the pin in by some device, which could be quickly made at the time. After the hole in the disk had been trued and the pin turned to the proper size, a device consisting of a 3½-in. diameter bolt *A*, a special casting *B*, a steel washer *C*, and a bronze nut *D*, were made.

A special wrench 6 ft. long was made to fit the nut *D*. The casting *B* was 24 in. in diameter by 24 in. long, and cored out in the center, the core being 4 in. in diameter so as to give plenty of clearance between it and the bolt *A*. The weight of this casting was 2380 lb. Both ends were faced off, one to rest on the disk over the pin, and the other for the bearing surface of the steel washer *C*, which fits into the face of the bronze nut. The nut was 12 in. in diameter, and the bearing side was faced and cupped as shown to receive a steel washer. Oil grooves were cut in the nut so that oil could be forced in between the washer and the nut to keep down the friction as the nut turned on this washer, which was 8 in. in diameter by $\frac{3}{16}$ in. thick.

From a piece of 6-in. steel shafting and a short length of 2-in. pipe, a battering ram 8 ft. long was also made. This ram swung from a chain the length of which allowed a swing of about 6 ft. To prevent injury to the pin when it was being rammed, a piece of ½-in. soft copper was used over the end of the pin.

When all the various parts were assembled and the ram hung in place, the large wrench was put on the nut *D*. A sling was then slipped around the wrench and over the hook of the chain tackle. By operating the wrench with the lifting tackle of the crane the crankpin was pulled into the disk for about 4 in. without the use of the battering ram. Then, while the lifting tackle was pulled so as to subject the wrench and pin to a tension, the battering ram was used to drive the pin in, two men operating the ram. After getting all the various parts assembled it required about two hours to pull the pin into its proper place. This engine has been running for a number of months under all conditions of load, and the pin seems to be as tight as it was the day we put it in.

It might be well to enumerate the symptoms of a loose crankpin.

Sympton 1. Pin heating up suddenly without apparent cause when there is a good bearing, the brasses properly keyed and the pin well lubricated.

Symptom 2. Occasional knocking or pounding, and heating of the pin, then tightening up and for a short while running smooth and cool. When a pin acts in this way one may rest assured that when the knocking and heating and the smooth running alternate, that the pin is loose and it should receive immediate attention.

Symptom 3. Trembling of a centrifugal oiler, when the brasses are properly keyed, or the turning of an oiler out of center.

Symptom 4. A breaking away of the beading on the back of the pin. Where pins are beaded over in this way and they become the least bit loose, the beaded end begins to disintegrate.

W. J. MAXWELL.

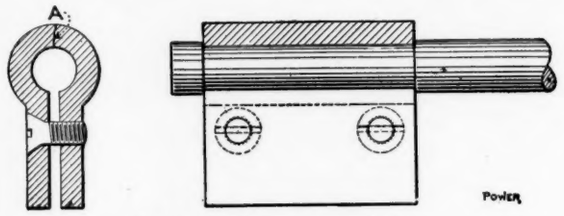
Indianapolis, Ind.

Broken Valve Rod Caused Pump Trouble

Some time ago I was troubled with a 6x4x10-in. single-acting boiler-feed pump stopping at one end or the other. I found that by changing the length of the valve rod it could be made to run again for some time, then it would stop on the other end. By changing the length of the valve rod the opposite way the pump would run again for some time then stop again as at first.

Changing the length of the valve rod to get the pump to run soon became monotonous and I took the pump

apart to see if I could locate the trouble. I found that the brass clamp on the end of the valve, as shown in the illustration, was broken at *A*, making it so loose that it would slip onto the larger part of the rod and stick there for some time, then do the same thing on the other side of the rod.



BROKEN VALVE-ROD CLAMP

A new clamp was made and put on and the pump gave no more trouble from that cause. Little breaks often give more trouble than large ones because the little breaks are not so apt to be seen or discovered as soon as the large ones.

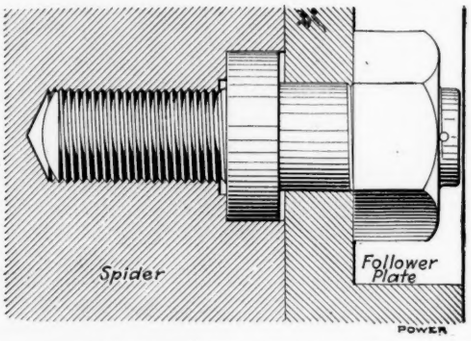
E. V. CHAPMAN.

Decatur, Ill.

Stud for Pistons

One of the common mishaps that occur to engines is the breaking of the studs that fasten the follower plate to the spider of the piston.

It is fortunate, indeed, if the nut and broken stud pass out with the exhaust steam without doing any damage;



SAFETY STUD FOR PISTON

but often a broken stud either smashes the piston, breaks the exhaust valve, twists the valve stem or breaks the cylinder head.

This happened in my plant so often that I decided to do a little investigating into the causes and remedies for such accidents. At the next break I secured a broken stud and by examining the steel with a microscope found it to be crystallized. To overcome this trouble I replaced all studs with ones made from Norway iron. I also changed the design of the stud so that, if the stud broke. it would not fall between the piston and the cylinder head. The stud was made with a collar, as shown in the sketch, and by reducing the diameter of the stud on the side next to the spider the stud would be more apt to break at this point.

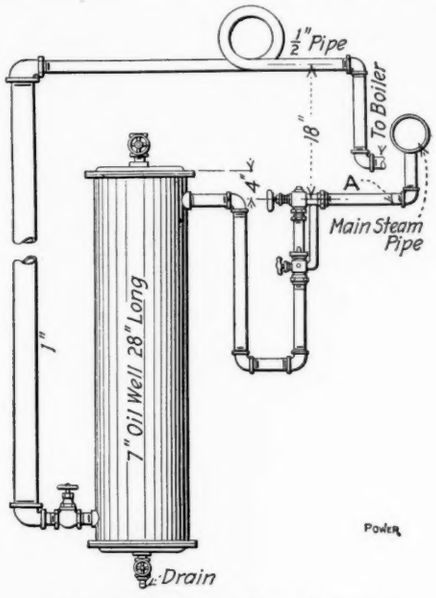
Since thus equipping all the engines I have had no more trouble.

A. RAUCH.

Swissvale, Penn.

Lubricator Will Not Work

Having had considerable trouble getting lubricators to work properly on locomotive cranes, one was made and connected as shown, which does not work properly. The



LUBRICATOR AND CONNECTIONS

lubricator feeds oil all right as far as the point *A*, and then backs in the sight glass. What is the trouble?

ROBERT RUSH.

Stewartsville, N. J.

Ammonia for Hot Bearings

In POWER I have often read articles pertaining to hot bearings and the different means the writers of these articles use to overcome them. I have never seen the following remedy given and it may prove of interest.

The refrigerating engineer need not have any fear as to the probability of a shutdown of the plant or engine, due to hot bearings, as the liquid ammonia he handles is one of the best things to cool hot bearings. Mix equal quantities of ammonia and water and pour it on the bearing or pin, as the case may be. It is surprising how quickly and easily this liquid will absorb the heat and leave the bearing perfectly cool; sometimes with frost on it, if enough liquid is used. Care must be taken not to get the liquid on the hands or face as it burns severely.

If the shaft or pin is very hot, do not pour the liquid in the bearing on the shaft or pin, but on the outside of the bearing, as the sudden chilling of the pin or shaft due to the liquid evaporating might crack or break one or the other. I have had eight hot bearings in my plant all at the same time, due to a breakdown of the oil pump supplying the lubricating system. All the bearings were cooled with this mixture and the engines kept running until repairs were made to the pump, when everything was restored to normal operating conditions.

We have four 250-ton ice machines and two 1000-kw. generators and several turbines and vacuum pumps. Needless to say these must be kept running all the time and this mixture of ammonia is valuable.

C. E. ANDERSON.

Chicago, Ill.

QUESTIONS BEFORE THE HOUSE

A Convenient Safety Valve Chart

Mr. Carr's article in the Dec. 24 issue exemplifies graphically and in a very clear and ingenious manner the Massachusetts rule for safety-valve equipment. If, however, this rule is carefully analyzed, using Napier's law for the flow of steam through orifices as a basis, all as shown by Mr. Carr, but figuring still further to get the valve lift, the results in Table 1, showing the lifts which must be obtained in practice with valves having 45-deg. seats to discharge steam at the rate called for by the Massachusetts rule, are obtained.

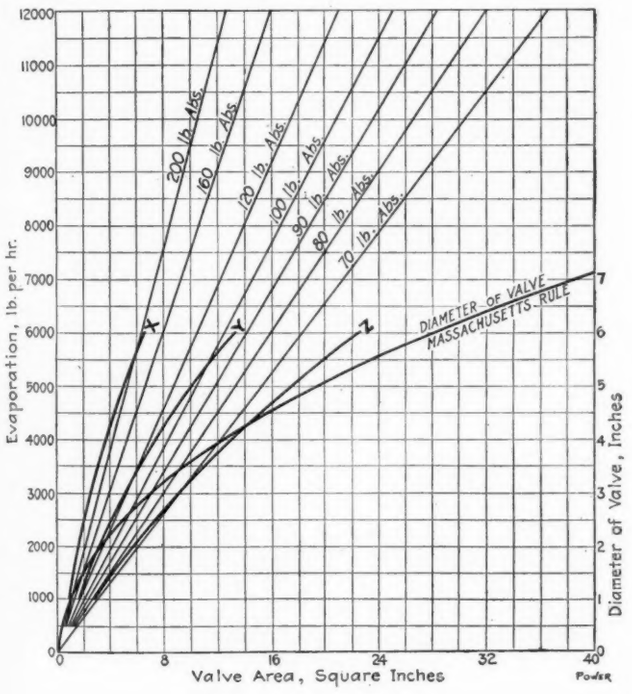
TABLE 1

Diam., in.	Lift, in.
2	0.067
3	0.100
4	0.133
5	0.167

TABLE 2

Diam., in.	Lift, in.
2	0.12
3	0.13
4	0.14
5	0.15

It may be noticed that this rule assumed the valve lift to be proportional to the diameter and also calls for lifts



SAFETY-VALVE CHART

considerably in excess of those found in almost all the well known makes of safety valves manufactured in this country at the present time.

In a certain line of safety valves now on the market, as made for stationary boilers, the lifts are about as shown in Table 2. Other makes, of which there are many in service, have the lift of the 4-in. valve as low as 0.04 in. and the great majority of 4-in. valves on the market today will show lifts less than 0.10 in.

Taking the line of valves in which the 4-in. size lifts 0.04 in., assuming that the lifts of the other sizes are graded about in the proportion of the actual lifts shown in Table 2, and figuring the valve diameters required, the line X was plotted on a reproduction of Mr. Carr's chart.

Proceeding in the same manner with a line of valves in which the 4-in. size lifts 0.08 in., the line Y was plotted, and using the lifts given for the valves in Table 2 in which the 4-in. valve lifts 0.14 in., the line Z was obtained.

As an example to show the practical working of this chart, assume an evaporation of 6000 lb. per hr., at 200 lb. absolute pressure. With the Z line of valves a 2½-in. diameter would be required, with the Y line a 3½-in. diameter and with the X line a valve 6 in. in diameter. The Massachusetts rule would be satisfied by a 3-in. valve.

For another example, take an evaporation of 5000 lb. per hr. at 100 lb. absolute pressure. The Z line would call for a 3½-in. valve, the Y line for a 5½-in. valve, the X line for two 5½-in. valves and the Massachusetts rule for one 4-in. valve.

In the preceding it is shown conclusively that the Massachusetts rule is safe, provided valves are selected which have lifts equal to or greater than shown in Table 1. Further, it is shown that the rules of the Board of Supervising Inspectors of Steam Vessels, the Canadian Steamboat Inspection Rules, the City of Philadelphia Rules, the State of Ohio Rules and the Massachusetts Rules would be much improved if they were revised to take into consideration the valve lifts. The objects of such rules are praiseworthy and are all steps in the right direction, but not until they are made safe and logical by introducing the element of valve lift will they correctly determine the requisite safety-valve equipment for all cases.

All of the above rules are now subject to criticism for the reason that it is very natural for the engineer in Massachusetts, for instance, to consider his safety valves adequate if they meet the requirements of the state law. He is liable to investigate no further, whereas if there were no such law he would probably study the subject carefully on his own account and also confer with the makers of the valves to find out their actual relieving capacity and compare it with his own data covering the maximum rate of steam production to be handled, thereby selecting valves of suitable size to take care of the maximum possible boiler evaporation.

F. C. BLANCHARD.

Bridgeport, Conn.

Boiler Scale

In the Oct. 29 issue, page 634, appeared a table giving the loss in boiler efficiency, due to the formation of scale, as determined by tests made by the engineering experimental station of the University of Illinois. The loss given varied from 7.2 per cent. for $\frac{1}{32}$-in. soft scale to 12.4 per cent. for $\frac{1}{16}$-in. soft scale.

The Bureau of Mines has a bulletin, No. 18, on "The

Transmission of Heat into Steam Boilers." This bulletin bases its conclusions both on tests made on small miniature boilers and on full-size models. No tests were made to determine the loss due to scale, but the following conclusion copied from this report may seem pertinent.

"The conductivity of metal forming the heating plate, even though the plate has a moderate amount of coating, is so high that any amount of heat that can be imparted to the dry surface by convection, can be transmitted through the heating plate without difficulty. Water has such high heat-abstracting ability that it can absorb heat as fast as the heating plate is able to conduct it. The slowness of the process of heat transmission into a boiler is due to the slowness with which heat, in present practice, is imparted to the dry surface."

The discrepancy in the conclusions drawn by two such excellent authorities seems to at least warrant discussion.

A review of the paper by the experimental station discloses several facts:

Its first series of tests was made on a locomotive boiler and the rate of combustion was higher than is generally at present used in stationary practice. In the three later tests made on single tubes only, the length of tubes is not given so that the rate of heat conduction cannot be computed. The water was raised in temperature from approximately 65 deg. to 112 deg. The conditions in these three tests are entirely different from actual conditions in a steam boiler. In a steam boiler, steam bubbles forming on the heating surface and rising, leave room for more water to reach the hot surface, thus causing a constant circulation inside the tube and this aiding in carrying off the heat from the plate. The great variations in the results are also worthy of note.

The Bureau of Mines gives the following formula for heat conduction:

$$H = \frac{C}{d}(T_1 - T)$$

Where

H = Quantity of heat transmitted per unit area of heating plate;

C = Average conductivity;

For iron the bureau gives 0.0005 for 1 in. thick.

d = Thickness;

T_1 = Temperature of dry surface;

T = Temperature of wet surface.

At the rate of 10 sq.ft. of heating surface per boiler horsepower, the heat transmitted per square inch per hour is:

$$\frac{34.5 \times 965}{10 \times 144} = 23.1 \textit{ B.t.u. per sq.in. per hr.}$$

*Marks and Davis give 970.4 as the latent heat of evaporation from and at 212 deg.

or

$$\frac{23.1}{60 \times 60} = 0.0064 \textit{ B.t.u. per sq.in. per sec.}$$

Transposing the formula of the Bureau of Mines for heat transformation we have,

$$T_1 - T = \frac{d \times H}{C}$$

This gives us a heat difference in this case of

$$\frac{0.1 \times 0.0064}{0.0005} = 1.3 \textit{ deg. } F$$

Dr. Joseph G. Rogers, in a paper read before the American Association for the Advancement of Science, gives the heat conductivity of scale as compared to iron in the ratio of 1 : 37.5.

This gives us the heat conductivity of scale as

$$\frac{0.0005}{37.5} = 0.00001333+$$

Assuming a ring of scale of the same dimensions as for the iron pipe, we would have a temperature difference of

$$\frac{0.1 \times 0.0064}{0.00001333} = 48 \textit{ deg.}$$

With both pipe and scale we should then have a temperature drop through the combined surface of approximately 50 deg.

Assuming the following values for an actual boiler and using the formula

$$E = \frac{T - t_f}{T - t_s}$$

where

E = True boiler efficiency;

T = Initial temperature of gas entering the boiler;

t_f = Temperature of air leaving the boiler;

t_s = Temperature of the steam.

T assumed at 2500 deg. F.

T_f assumed at 600 deg. F.

T_s assumed at 350 deg. F.

For a clean boiler we would then have a true boiler efficiency of

$$E = \frac{2500 - 600}{2500 - 350} = \frac{1900}{2150} = 88.37 \textit{ per cent.}$$

With scale in the tube the drop will become about 50 deg. more than in the clean tube and it seems fair to assume the temperature of the gas leaving the boiler would be 50 deg. hotter or 650 deg.

Our efficiency for the scaled tube would then be

$$E = \frac{2500 - 650}{2500 - 350} = \frac{1850}{2150} = 86.4 \textit{ per cent.}$$

This gives us a drop in efficiency of only 2 per cent., which certainly is considerably less than that given by the University of Illinois.

Is it not a case of poor conductivity at the joint of scale and iron which causes this discrepancy? The great variation in figures obtained might be due to the different composition of the different scales. The figures also seem to show very little additional loss as the thickness of scale is increased.

It would seem as though a test upon artificially made scale, the composition of which is known, might throw considerable light on the subject.

JOHN BAILEY.

Milwaukee, Wis.

❖

The use of steam-turbine-driven centrifugal pump units to carry the peak of the load in water-works pumping stations is exemplified in the new water-works of Youngstown, Ohio. It is stated that contracts were let on Dec. 14 for two 7,500,000-gal. pumping units for the new pumping station at Youngstown. One contract was for a triple-expansion reciprocating pump, let to the William Tod Co., of Youngstown, at a price of $72,110, for a pump with a guaranteed duty of 163,000,000 ft.-lb. A contract was also let to the Kerr Turbine, with a guaranteed duty for the unit of 80,000,000 ft.-lb.

INQUIRIES OF GENERAL INTEREST

High- and Low-duty Pumps—What is the difference between a high- and a low-duty pump?

K. N. F.

The ordinary steam pump taking steam during the full stroke is called a low-duty pump. Formerly, a high-duty pump was always understood to be one of crank and flywheel type; but now, some prefer the definition that a high-duty pump is any pump that uses steam expansively.

Vapor Pipe Use—What is the advantage of having a vapor pipe connected with the suction pipe from a feed pump to an open heater?

K. F. N.

A vapor pipe in a pump suction from an open heater prevents a part vacuum and reduction of pressure in the suction pipe which would result in the release of vapor, thereby causing the pump to slip the same as though there were air in the pipe.

Removing Oil Stains—How can oil stains be removed from walls and floors?

H. E. R.

Grease spots can be drawn out of floors by covering them with powdered magnesia, and out of walls or ceilings by covering the spots with a thick paste of magnesia and water, subsequently removing the magnesia. Surface spots can be removed by any alkali wash, such as water containing ammonia, wood ashes, soda, potash or any alkali that will not injure the material to be cleaned.

Crosshead Alignment—How can the alignment of a crosshead shoe be tested?

N. F. K.

Loosen the piston-rod packing and, starting with the piston at the head end of its stroke, observe whether the gland is moved laterally as the crosshead is moved to the opposite end of the stroke. The direction of the movement of the gland, if it moves at all, indicates the direction in which the crosshead shoes are out of line. Correct for one shoe and then the other until the above test shows no movement of the gland.

Home-made Pipe Covering—Will a mixture of sawdust and flour make a satisfactory pipe covering? Is there any other cheap covering?

C. N. T.

A mixture of flour paste and sawdust should make a fairly good covering for steam pipes; but it probably could not be applied and held properly in place without first wrapping the pipe with wire cloth for a foundation. The effectiveness of the covering would depend on the porosity or proportion of air-cell spaces in the covering.

A very good cheap covering is made up of unsized building paper, after first covering the bare pipe with asbestos paper, and there should be a final covering of asbestos paper to prevent the covering from taking fire or communicating it to combustible materials in its vicinity.

Belt Power—With the same widths of belts, the arcs of contact the same and the belts running at the same speed in feet per minute, does it make any difference in the power transmitted by the belts whether the pulleys are 3 ft. or 6 ft. in diameter? Does the increased area of contact on the larger pulley give the belt a better grip so that it would transmit more power? Does the increased leverage on the larger pulley make the belt more powerful?

T. T.

Under the conditions named in the first question, the same horsepower would be transmitted irrespective of the diameter of the pulleys. The number of degrees in the arc of contact, and not the area of contact, is the determining factor, for friction is directly as the total pressure and independent of the area.

Increased leverage does not come into the question or rather is taken into account when it is assumed that the same number of feet per minute is traveled whether the pulleys be large or small.

Water Pressure Helps Pump—Why is it that a pump having steam and water cylinders of the same diameter can, nevertheless, deliver water into the boiler from which it takes its steam supply, the boiler pressure being 110 lb. and the city water pressure 85 lb.?

W. A. O.

The inlet pressure of the water assists in the water end of the pump, making that part, to an extent, a water engine, so that the steam end, theoretically, has to overcome only the difference between 110 lb. and 85 lb., or 25 lb. Practically, this pressure is somewhat greater, due to the friction of the pump parts and the water, etc., which has the effect of increasing the pressure to be pumped against.

Net Lift of Vacuum Pump—A wet vacuum pump is placed so that its cylinders are 4 ft. below the water level (maintained by a float) in the surface condenser from which it draws. It discharges into an open tank at such a height that a gage on the delivery pipe at the level of the cylinders shows 5 lb. pressure. If the vacuum in the condenser is 28.2 in., what is the equivalent total lift in feet through which this pump works?

F. J. P.

In creating a vacuum of 28.2 in., a pump does the equivalent of lifting water a height of

$$28.2 \times 1.132 = 31.92 \text{ ft.}$$

1.132 ft. being the head in feet of water corresponding to 1 in. of mercury. But 4 ft. of this head is due to the water itself so that the net lift of the pump is

$$31.92 - 4 = 27.92 \text{ ft.}$$

The discharge head corresponding to 5 lb. is

$$5 \times 2.309 = 11.55 \text{ ft.}$$

2.309 ft. being the height of a column of water giving a pressure of 1 lb.

The total net lift, therefore, is

$$27.92 + 11.55 = 39.47 \text{ ft.}$$

Centrifugal Pump Horsepower—A centrifugal pump, furnishing salt water for a condenser, has a horizontal shaft, the center of which is 9½ ft. above the water in the intake. A gage, on the delivery pipe, 4 ft. above the shaft, reads 7 lb. If the pump delivers 37,000 cu.ft. per hour and its mechanical efficiency is 55 per cent., what horsepower does it take to drive it?

P. J. F.

From the intake level to the position of the gage, the pump lifts the water

$$9.5 + 4 = 13.5 \text{ ft.}$$

Salt water weighs about 64 lb. per cu.ft., which is also its pressure per square foot for each foot of head.

$$\frac{64}{144} = 0.444 \text{ lb.}$$

will, therefore, be the pressure per square inch per foot of head, and the total to the level of the gage,

$$13.5 \times 0.444 = 5.994 \text{ lb.}$$

The pressure in the discharge pipe being 7 lb., the total head is

$$5.994 + 7 = 12.994 \text{ lb. per sq.in.,}$$

or

$$12.994 \times 144 = 1871.136 \text{ lb. per sq.ft.}$$

In 1 min. there is pumped,

$$\frac{37{,}000}{60} = 616.666 \text{ cu.ft.}$$

and against a pressure of 1871.136 lb. per sq.ft., the work done is

$$616.666 \times 1871.136 = 1{,}153{,}865.953 \text{ ft.-lb. per min.,}$$

which corresponds to

$$\frac{1{,}153{,}865.953}{33{,}000} = 34.965 \text{ hp.}$$

But, as the pump efficiency is only 55 per cent., the actual power required is

$$\frac{34.965}{0.55} = 63.57 \text{ hp.}$$

ENGINEERS' STUDY COURSE

MENSURATION—PART II

QUADRILATERALS

A plane is a flat surface like that of a piece of sheet packing, or the floor, or the wall of the engine room. The edges of a plane figure may be straight or curved. A *quadrilateral* is a plane figure bounded by four straight lines, but the lines do not necessarily have to be parallel lines.

A *parallelogram* is a quadrilateral whose opposite sides are parallel. A *rectangle* is a parallelogram, all of whose angles are right angles as in Figs. 1 and 2.

All figures have a *base,* which is the underside or side on which the figure stands. The *altitude* of a figure is its height or the distance between the base line and the top; in a parallelogram, the altitude is the distance between the top and bottom parallel lines.

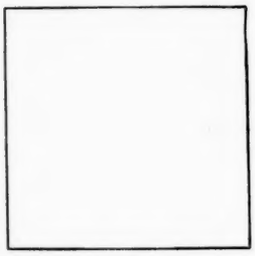


FIG. 1.

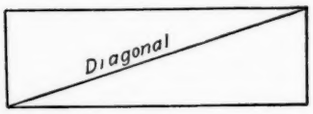


FIG. 2.

FIG. 4.

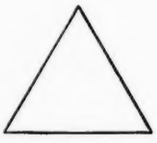


FIG. 5.

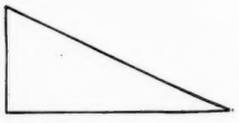


FIG. 6.

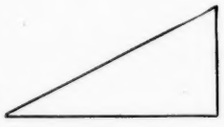


FIG. 7.

FIG. 8.

Rule: *To find the area of any parallelogram, multiply the base by the altitude.*

This rule is seen to be true by studying Fig. 3, which is a plane figure 12 in. long and 6 in. wide. Applying the rule to it, we have

$$12 \times 6 = 72 \text{ sq.in.}$$

You can prove that this rule is correct by simply counting the number of squares which you will find to be seventy-two. We see that this rule is correct for a rectangle as well as a square.

If we know the area and either the base or the altitude of a parallelogram, we can easily find the unknown dimension.

Rule: *Divide the area by the given dimension to get the unknown dimension.*

Example: A rectangular cooling pond has a surface area of 37,944 sq.ft. If the pond is 204 ft. long, how wide is it?

$$\text{Area} = \frac{37{,}944 \text{ sq.ft.}}{204 \text{ ft.}} = 186 \text{ ft.} = \text{width}$$

$$\text{Length} =$$

Example: How many square yards of asbestos will be required to cover a rectangular feed-water heater 8 ft. high, 5 ft. wide and 5 ft. long

$$\frac{8 \times 5 \times 4 \text{ (sides)} + (5 \times 5)}{9} = 20.56 \text{ sq.yd.}$$

Here we divided the total area of the sides and top by 9

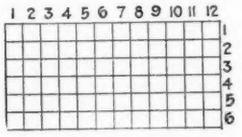


FIG. 3.

because our answer is to be in square yards, and 9 sq.ft. equals 1 sq.yd.

TRIANGLES

A *triangle* is a plane figure having three sides.

A *right-angled triangle* is any triangle containing a right angle.

By drawing a *diagonal* through the rectangle, Fig. 2, we produce two right-angled triangles. Other such triangles are shown in Figs. 6, 7 and 8.

An *isosceles triangle* is one having two of its sides of equal length, as Fig. 4.

An *equilaterial triangle* is one having its three sides equal in length, as Fig. 5.

One of the interesting things about triangles is that the sum of all three angles will equal 180 deg., or two right angles. Thus, studying the angles in the triangles, Figs. 2 to 8, we find that the sum of the angles of each triangle equals two right angles.

In a right triangle, which is a shorter name for a right-angled triangle, the side opposite the right angle is called the *hypothenuse.* The sides forming the right angle form the base and altitude.

If you will study Fig. 9, you will see that the sum of the squares of the sides forming the base and altitude is equal to the square of the hypothenuse. As this relation between the base and the altitude and the hypothenuse is always true of a right triangle, we can easily find the length of one side of a right triangle when two sides are known. We can also easily produce formulas for calculations involving the right triangle. Let

A = Altitude;

B = Base;

C = Hypothenuse.

We have these formulas for the right triangle.

$$A = \sqrt{C^2 - B^2}$$
$$B = \sqrt{C^2 - A^2}$$
$$C = \sqrt{A^2 + B^2}$$

Example: A steel stack 50 ft. high is to be mounted on a base, the height of which is 4 ft. from the ground. Three feet from the top of the stack is a ring to which six guy cables or wires are to be fastened to hold the stack. Each cable is to be fastened to piers located 30 ft. along the ground from the stack. Allowing 2 ft. to each cable

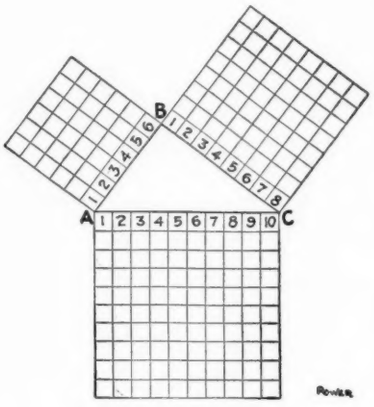


FIG. 9.

for fastening, how many feet of cable will be necessary to support the stack?

Here the guy cables form the hypothenuse. The base is 30 ft. and the altitude is

$$50 - 3 + 4 = 51\ ft.$$

Applying the formula for finding the hypothenuse

$$C = \sqrt{51^2 + 30^2} = 59.16 + ft.$$

Adding 2 ft. for fastening

$59.16 + 2 = 61.16 + ft.$ = *length of cable needed for one guy*

Then there will be

$$61.16 \times 6 = 366.96, \text{ say } 367\ ft.$$

of cable needed to complete the job.

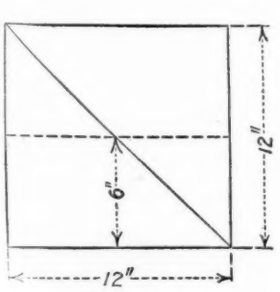


FIG. 10.

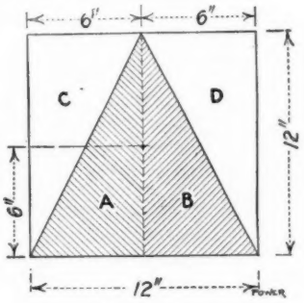


FIG. 11.

Suppose we have a rectangle as in Fig. 10, the area would be

$$12 \times 12 = 144\ sq.in.$$

If it is divided in half, as by the dotted line, the total area will, of course, be divided in half. If a diagonal is drawn, forming the two right triangles, the area is divided into two equal parts. If instead of drawing one diagonal, we make two, one in each half of the square, forming four right angles, *A*, *B*, *C* and *D* respectively, Fig. 11, all the triangles will be of equal area and the shaded triangles, *A* and *B*, will be equal in area to the two unshaded ones, *C* and *D*.

A little study of these triangles will show that a simple rule may be written for finding the area of a triangle. Consider the half of a rectangle containing the triangles *A* and *C*, Fig. 11. The dotted line across this rectangle divides it into two smaller rectangles, each 6x6 in., or 36 sq.in. in area. For the present, consider only the rectangle containing the triangles *A* and *C*. The area of this rectangle is

$$12 \times 6\ in. = 72\ sq.in.$$

We can now see that the shaded part of *A* above the horizontal dotted line, will exactly fill the unshaded part of *A*, the lower left rectangle. Also the shaded part, *A*, will just fit into the unshaded part, *C*.

Now, as the area of the left rectangle is 72 in. and as it is divided into two triangles of equal areas, the area of each triangle must be $\frac{72}{2} = 36$ sq.in.

Rule: *The area of a triangle is found by multiplying the base by one-half the altitude.*

Applying the rule to the triangle *A*, we have

$$Area = base \times \frac{altitude}{2} = 6 \times 6 = 36\ sq.in.$$

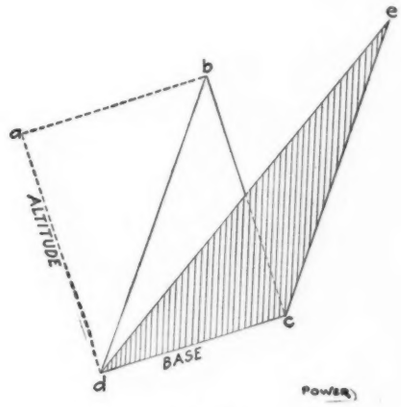


FIG. 12.

This rule may also be expressed

$$Area = \frac{base \times altitude}{2}$$

Example: An ash hopper, shaped like an inverted pyramid, is to be made up of four triangular pieces of steel plate, each with an 8-ft. base and a 10-ft. altitude. How many square feet of plate are required and what must be the length of each of the four angle-irons to which the sheets are to be riveted? Nothing is to be allowed for the space which the gate will occupy.

The total area of the four plates will be

$$\frac{8 \times 10}{2} \times 4 = 160\ sq.ft.$$

The length of an angle-iron for one side will be (see formula for finding the hypothenuse of a triangle)

$Hypothenuse = \sqrt{10^2 + 4^2} = 10.77\ ft.$ = *length of one angle iron*

The rule

$$Area = \frac{base \times altitude}{2}$$

is also true for a triangle like *A* in Fig. 12. Assume the

base *de* of the rectangle *abcda* to be 12 in. and the altitude 16 in. Then the area of the triangle *dbcd* is

$$Area = \frac{12 \times 16}{2} = 96\ sq.in.$$

The shaded triangle *decd* has a base *dc*, which is 12 in., the same as in the triangle *dbcd*. As the altitude of any triangle is the length of a line drawn *perpendicular from the apex to the base*, the altitude of the triangle *decd* will be 16 in. or the same as for the triangle *dbcd;* consequently the area will be

$$Area = \frac{12 \times 16}{2} = 96\ sq.in.$$

which is the same as the area of the triangles *dabd* and *dbcd*.

To find the altitude or base of a triangle when the area and base or altitude are given:

Rule: *Double the area and divide by the given dimension.*

Example: A lot shaped like a right triangle is 57,607 sq.ft. in area and is used for storing coal. The base of the triangular lot is 157 ft.; what is the altitude?

(b) How many lineal feet of 12-in. wide boards are necessary to inclose the lot with a solid fence 12 ft. high, allowing a doorway 11 ft. wide for the passage of coal cars?

The altitude is

$$\frac{57{,}607 \times 2}{157} = 733.847\ ft.$$

The length of the hypothenuse would be

$$\sqrt{733.847^2 + 157^2} = 750.45\ \ ft.$$

The length of fence is

$$750.45 + 733.847 + 157 = 1641 + ft.$$

The number of lineal feet of lumber required is

$$(1641 - 11) \times 12 = 19{,}560\ ft.$$

For practice, the student should work out all the examples given in this lesson. Many new examples can readily be found, as the triangle is involved in many practical problems.

Answers to Last Week's Problems

(1) (a) 2.067. (b) 4.134.
(2) An acute angle.
(3) 11,160.

❖

The Current-O-Scope—Such is the name given to a little celluloid novelty brought out by Fairbanks, Morse & Co., Chicago, to illustrate the action of an induction motor. The whole device is only about 3 in. square and goes in a little flat leather envelope. The device itself is somewhat like numerous calculating charts of various kinds that have been brought out, so far as its construction is concerned, but is entirely different in all other respects. On the face of the chart is the representation of the cross-section of an induction motor with the stator and rotor windings shown. In the center is a vector diagram, which shows the manner in which the current varies in the three different phases, which latter are represented as red, green and black for purposes of distinguishing them. At other openings in the chart are arrows showing the direction of the currents in the lead wires, and other marks show the direction of the current through the various parts of the windings as well as the strength and direction of the magnetic field. With the device is a little instruction book concerning its use. Altogether it is a very ingenious means of demonstrating the current action in an induction motor, and is well worth the price of 25c., which is being asked for it.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Men of the ancient Egyptian upper crust, says an Egyptologist, "commonly lived to be 110 years old. They consumed 100 jars [Egyptian for 'can'?—Editor] of beer daily and had their wives tickle their feet." According to this theory, a centipede, with its choice collection of feet, should live 5500 years. While we are tickled that the Egyptians had their feet tickled, we are jarred somewhat by that beer-consumption feat. The last Metropolitan Museum Egyptian we saw looked like he'd drunk himself black in the face. He looked jarred, or pickled, not tickled.

❖

If you were asked to name offhand ten famous men in the history of steam engineering, whom would you say and in what order? Dig up a postcard and send your list to "Power."

❖

Lincoln Boffum, who is doing the pumping for our village water supply out on the meadows, is grinning yet over how he kidded a city chap who was out that way shooting hare. The city fellow was tearing round in circles when he spied Link coming across the yard with a barrow of coal, and rushing up, hollered:

"Say, you; I lost my hare. Seen it?"

Link kind of snickers. Then pulling off his cap, and displaying one of the highest foreheads in Harris County, drawls out:

"I lost all of mine, and I ain't makin' the fuss you be."

❖

One of J. P. Morgan's partners says that there is no such thing as a money trust; it's a spectre. Now we know why on pay-day folks ask: "Has the ghost walked yet"? This ghost exhibits the right spirit usually and he (or it) can't walk too often to suit us.

❖

Even if we have no money ourselves, we like to talk about it. Here's another. The Union Electric Light & Power Co., St. Louis, loans money to its needy employees who might, otherwise go to the loan sharks. This succor by the company saves the other suckers from being badly bitten by the sharks, and, as Old Cap'n Prouty, down Cape Cod way, used to say, "Sharks is h-ll!" (You'll have to guess at the missing letter).

❖

Continuing, how would you like to earn a hundred thousand dollars in real money? You can if you know a better fuel than gasoline for an internal-combustion engine. All Europe and the United States (except possibly Dooley's friend, Jawn D.) are ready to make you rich when you get the answer.

❖

Here's another money hunch. Dr. Hodge, Niagara Falls, N. Y., offers to pay a thousand dollars to anyone who will give him one good reason for the habitual use of tobacco. As the New York Fire Commissioner has josjohnsoned our chances of smoking in this office, we hereby offer $2000 for a good excuse for breaking this law. The money will be cheerfully paid out of our next week's wage—er, salary.

❖

A distinguished Frenchman in our midst says he cannot give an offhand formula for the significance of laughter. That we should become apprehensive! We can laugh, even take a smile, and usually we don't care one of those little tinker things what we laugh at either—but the "smile" must be good. Ding bust the reason, always excluding the sneer and the venom. Let's live to laugh and laugh to live. If you're just "folks," laugh and grow content; if you think you're "somebody," relax occasionally and let dignity go hang!

❖

Friend Stone, over to Boston, has mortared and pestled these little tablets for our mental digestion and to give publicity to the Elliott Power & Accessories:

"Success Comes in Cans. Failures in Can'ts!"

"Brains Never Swell the Head."

"Seek, and Ye Shall Find; Knock and Nothing Shall Be Opened Unto You!"

The Mixed Pressure Steam Turbine

SYNOPSIS—Description of a mixed-pressure turbine being put out by the British Thomson-Houston Co. in which the high-pressure and low-pressure steam is conducted through separate nozzles in the second stage. The general governing features of mixed-pressure turbines are also discussed.

In a paper on the "Development in Curtis Steam Turbines," read recently before the Manchester Association of Engineers, R. F. Halliwell devotes considerable space to the mixed-pressure type and describes the latest practice of the British Thomson-Houston Co. in this respect. His remarks were in part as follows:

In mixed-pressure turbines the low-pressure steam is generally admitted to an intermediate stage where it mixes with steam which has already done work in the high-pressure stage. In many cases, however, where the utmost economy under high-pressure conditions is not essential, a special high-pressure stage is not employed, the high-pressure steam and low-pressure steam both being admitted to the same first-stage wheel, of course, through separate nozzles, the two supplies of steam not mixing until both have done work in the first stage. This arrangement presents many advantages, inasmuch as the utilization of the low-pressure steam available is not affected by the quantity of high-pressure steam which is being admitted to the turbine.

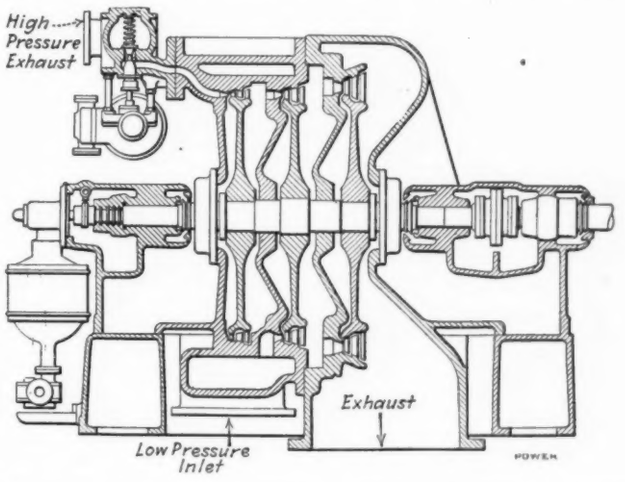
The same cannot be said of the ordinary mixed-pressure turbine, with a separate high-pressure stage, in which the low-pressure steam mixes with the already partially utilized high-pressure supply, the two together passing through common nozzles to the second stage. In this case, since the second-stage nozzles have to be designed to pass a certain maximum quantity of steam at the low-pressure inlet pressure, if from any cause the amount of high-pressure steam being used is larger than that allowed for, the quantity of low-pressure steam which can pass through the nozzles will be correspondingly reduced, with the effect that the turbine is incapable of utilizing its full quantity of low-pressure steam, although there may be an ample supply available.

The great advantage of having separate low-pressure inlet nozzles will therefore be apparent, but in order that the pressure in the second stage may not affect the flow of steam through the first-stage nozzles, it is necessary that the second-stage pressure be not greater than about 58 per cent. of the first-stage pressure, that is, the critical point below which the weight of discharge through a nozzle is independent of the discharge pressure and depends solely on the initial pressure. To be well on the safe side of this critical point it is necessary that a considerable proportion of the energy be utilized in the first low-pressure stage, the Curtis turbine being practically the only one which permits this to be done without loss of efficiency. With the reaction type in which steam is admitted around the whole circumference, this arrangement is impossible.

The British Thomson-Houston Co. has recently patented and are now building a new type of mixed-pressure turbine, shown in the illustration, in which the advantages mentioned are combined with excellent economy on high-pressure steam. This turbine has a separate high-pressure stage, the steam from which, instead of mixing with the low-pressure steam and then passing to the second stage goes into separate nozzles in the second stage, the two supplies not mixing until they have passed through the second stage. Owing to the provision of special nozzles in the second stage to receive the partially utilized high-pressure steam, these nozzles can be designed to suit high-pressure conditions.

It should be noted that when this turbine is operating with low-pressure steam alone, the pressure in the space surrounding the high-pressure wheel is only that found at the entrance to the third stage, which being quite low produces small rotation losses, so that the loss in efficiency as a low-pressure turbine is small.

This design of turbine has been criticized because when operating under mixed-pressure conditions with a quantity of low-pressure steam below the normal, the inlet pressure of the low-pressure steam is lower than it would be if the pressure were kept up by the admixture of the high-pressure steam which is being used, and that therefore the low-pressure steam consumptions suffer. It would certainly seem that to claim an advantage for the maintenance of pressure in an ordinary mixed-pressure turbine, due to the admission of high-pressure steam, is in the nature of making a virtue of a necessity, and that any slight theoretical gain in economy under certain abnormal conditions is more than counterbalanced by the ability to utilize at all times the full quantity of exhaust steam. Also in the case of turbines working with regenerative accumulators, the reduction in pressure as the quantity of low-pressure steam decreases permits full advantage to be taken of the regenerative capacity by using an automatic shutoff valve on the far side of the accumulator.



SECTION THROUGH THOMSON-HOUSTON MIXED-PRESSURE TURBINE

In the British Thomson-Houston mixed-pressure turbines the low-pressure controlling valve, which is usually of the butterfly type, is operated by a bell crank actuated by a spiral cam at the end of the camshaft. The cams are arranged so that the first high-pressure valve is not opened until the low-pressure valve is wide open, so that so long as there is sufficient low-pressure steam to deal with the load no high-pressure steam is used.

In many cases where mixed-pressure turbines are operated in electrical connection with reciprocating engines, from which the low-pressure steam is obtained, no controlling valve for the low-pressure steam is fitted, or if fitted is rendered inoperative by the turbine being kept to speed through the interlocking of the engine and turbine generators, and utilizing all the exhaust steam available. High-pressure steam can be admitted when dealing with heavy loads by adjusting the synchronizing gear, so that if left to itself the turbine would run a little slower than the normal speed of the station. In this way the turbine governor will only come into operation when the total load is such as to cause the station speed to drop a certain amount below the normal. A set of 3000 kw. capacity has been recently supplied to the Lancashire & Yorkshire Ry. for their Formby station.

Another method of governing mixed-pressure turbines, when the turbine receives the exhaust from an engine or engines not electrically connected with the turbine, is to arrange the low-pressure controlling gear to operate a bypass either to a lower stage or to the condenser. By this means, should the quantity of exhaust steam be more than sufficient for the load on the turbine, the bypass opens, and reducing the back pressure on the engine, enables it to do its work with less steam, the quantity of which is readjusted by the engine governor. With this arrangement the back pressure on the engine, and consequently the quantity of steam used by the engine is kept down to the minimum required for the load on the turbine, and maximum combined efficiency is thereby obtained.

Where mixed-pressure turbo-alternators run in parallel with high-pressure sets of similar or larger size, it becomes necessary to slightly modify the governor gear to permit a proper distribution of load to be secured in the event of a partial or complete cessation of the low-pressure supply. This is easily and simply provided for by a duplex arrangement of the pilot valve regulating the oil supply to the servo motor. The valve itself, which remains as before, is surrounded by a sleeve or hollow outer valve, actuated by a piston exposed to the low-pressure inlet pressure in such a way that if this inlet pressure falls the position of the ports admitting oil to the servo motor is altered; also the camshaft is rotated sufficiently to admit enough high-pressure steam to deal with the load without the governor being affected, and therefore without any change in speed. Restoration of the low-pressure inlet pressure results in the replacing of the parts in their original positions.

❖

On Figuring the Indicated Horsepower

By Julian C. Smallwood

SYNOPSIS—The author demonstrates that unless the area of the diagram from one end is three times that of the diagram from the other, less than one per cent. of error is incurred by using the average diagram and piston areas in computing the horsepower. He also gives a formula for setting an adjustable planimeter so that it will read directly in terms of horsepower.

❖

When using the formula

$$I.hp. = \frac{PLAN}{33{,}000}$$

for a mathematically exact result, it is necessary to calculate separately the horsepowers on the two sides of the piston of a double-acting steam engine and add them together to get the total horsepower. This is because the area on the crank end is less than that on the head end by the amount of the piston-rod cross-section. The steam-engine code of the A. S. M. E. recommends that the average mean effective pressure and the average area be used in the formula so that the result may be obtained by a single computation, N then signifying the number of strokes instead of the number of revolutions. The code further states that where extreme accuracy is required, the first mentioned method may be used; but it does not say how much error may be involved by not using it nor under what circumstances the error may be excessive.

A brief consideration will show that the more nearly is the area on the crank end equal to that on the head (that is, the smaller is the area of the piston rod relative to that of the cylinder), the less error is there in the approximate calculation. Also, the less difference is there between the mean effective pressures on the two sides of the piston, the less error is there. When they are equal, the results from the two methods are the same.

The following is a rational formula by which the per cent. of error ensuing from the approximate method may be determined for any conditions.

Let

R = Ratio of the m.e.p. on the crank end to the m.e.p. on the head;

d = Diameter of the piston rod, inches;

D = Diameter of the cylinder bore, inches.

Then

$$\textit{Per cent. of error} = 50 \times \frac{d^2}{D^2} \times \frac{1 - R}{1 + R}$$

As an example, let $d = 2$ in., $D = 10$ in., and $R = 3$. Then

$$\textit{Per cent. of error} = 50\tfrac{4}{100} \times \frac{1 - 3}{1 + 3} = 1\%, \textit{ minus}$$

It is hardly worth while, because of instrumental errors, to calculate the result closer than to 1 per cent. of error, so we may conclude that under these conditions if the mean effective pressure on one end is less than three times what it is on the other, the approximate calculation is sufficiently accurate. It is apparent, too, that with any engine with a valve setting giving fair division of the load, so that the mean effective pressures are reasonably equal, there is entirely negligible error from the approximate method. With some engines the cylinder work may be fairly divided at normal loads, but at light loads quite unequally so. In such cases the formula will show whether or not the correct method should be used. A convenient rule following from the formula is as follows:

If the mean effective pressure on one end is not greater than

$$\frac{50\,d^2 + D^2}{50\,d^2 - D^2}$$

times the mean effective pressure on the other, then the error is less than 1 per cent.

Taking advantage of the approximate method, the indicated horsepower of a steam engine may be readily obtained by a direct reading of a polar planimeter without calculation, provided the planimeter has an adjustable arm. It is merely necessary to adjust the length of this arm (namely, the distance between the tracing point and the pivot of the planimeter), according to the result obtained by the following formula:

Let

C = Desired length of the adjustable arm, inches;
l = Length of the indicator diagram, inches;
S = Scale of the indicator spring;
K = Product of LAN in the $PLAN$ formula: L in feet, A the average of the two areas, square inches, N the r.p.m.;
w = Diameter of record wheel, inches;
G = Number of graduations on the record wheel;
X = Number of graduations selected to read one indicated horsepower.

Then

$$C = \frac{10{,}500\ l\ G}{S K w X}$$

With the adjustable arm set to equal the calculated length C, the i.hp. is read directly from the record wheel according to the selected scale X, after traversing the

FIG. 1. HOOD REMOVED, SHOWING ACCESSIBILITY OF VALVE

head and crank-end diagrams in the usual way to obtain area.

As an example, take a 10x16 engine at 160 r.p.m., having a $1\frac{7}{16}$-in. piston rod. The indicator diagrams are 3.25 in. long and the scale of the indicator spring is 60 lb. to the inch. The planimeter has a record wheel 0.79 in. in diameter bearing 100 graduations. A vernier subdivides each graduation into tenths so that if one graduation on the wheel equals one horsepower, the results may be read to one-tenth of a horsepower. Hence a convenient value of X is 1. The area on the head end is 78.5, on the crank is 76.9 sq.in., and the average area is 77.7 sq.in. Now,

$$K = \tfrac{16}{12} \times 77.7 \times 160 = 16{,}576$$

$$C = \frac{10{,}500 \times 3.25 \times 100}{60 \times 16{,}576 \times 0.79 \times 1} = 4.34\ in.$$

For obtaining the results during the progress of a test, this method will be found very convenient as it saves the time and labor of slide-rule work without impairing arithmetical accuracy. The indicators should give a constant length of diagram equal to that used in the calculation for C. An average value of the r.p.m. is used in the formula for C. If the speed changes, the arm C may be readjusted to a new length equal to that first calculated multiplied by the ratio of the first to the second number of revolutions per minute.

Boylston Improved Steam Trap

The Boylston improved steam trap, illustrated herewith, is designed with especial view to accessibility and low maintenance cost. By using a reversible valve seat doubly long life is given to that important part of the apparatus. The disk can be removed by lifting the valve hood, Fig. 1, which exposes the disk, and taking out the

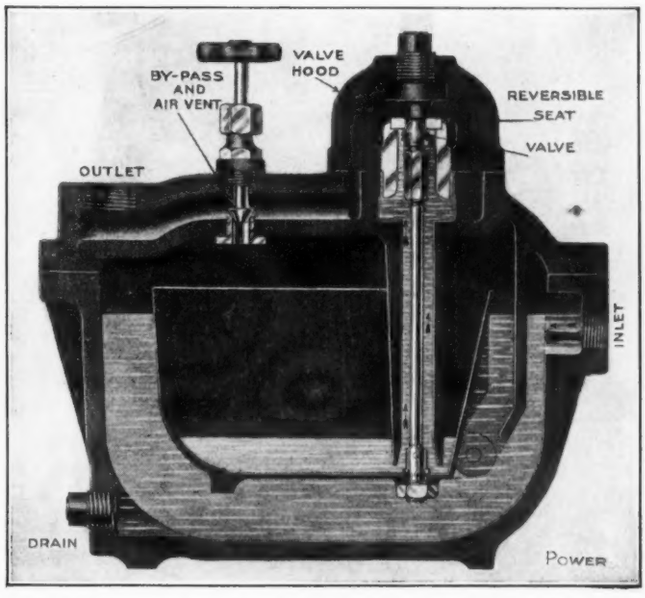


FIG. 2. SECTIONAL VIEW THROUGH TRAP

small pin which fastens the disk to the stem. The seat can be removed from the hood by taking out the brass bushing which holds it in place.

Another feature is the built-in bypass and air-vent valve, Fig. 2. With this arrangement extra piping, fittings and labor are saved.

Due to the fact that the valve stem is anchored close to the bucket hinge, producing thereby maximum leverage, it is possible to ues a valve of unusually large area and, hence, obtain large capacity.

This trap is manufactured by the Western Kieley Steam Specialty Co., 116 West Illinois St., Chicago, Ill.

Developments in Oil Burning*

By E. H. Peabody

SYNOPSIS—Methods of introducing air to secure proper mixture with the oil spray. Principal oil-burning systems installed in torpedo-boat destroyers.

❖

Air Distributors

Great delicacy is required in introducing the air for combustion, very slight changes affecting the results in unsuspected ways, and while almost any method may result in smokeless combustion, maximum economy and capacity can only be secured by careful and intelligent design.

It is not necessary to give the air a whirling motion but, judging from rather exhaustive experiments, better gas analyses are secured, lower air pressures are required, and less refinement of adjustment is needed if the air is brought into contact with the oil spray with the right sort of a twist. We have found the impeller plate illustrated in Fig. 9 most effective in accomplishing this mixture, and most satisfactory results have been obtained with it.

Fig. 10 shows a cast-iron truncated cone, with slots cored in the side so arranged as to give the air a whirling motion. It was tried with the end closed and all the air passing through the slots, and also with the end open, some of the air passing through the slots and some through the end of the cone around the burner. The burner was located at the end of the cone as shown in the cut, and also pushed into the inner end of the cone, and also in intermediate positions. The whirling motion of the air obtained with this arrangement is of a different character from that obtained with the impeller plate.

Fig. 11 shows truncated cones made up of concentric rings of sheet iron with air passages between them, and so formed as to direct the air toward the axis. The angle of one set of rings was 7½ deg. and that of the other set, 15 deg. from the axis. There was no whirling motion.

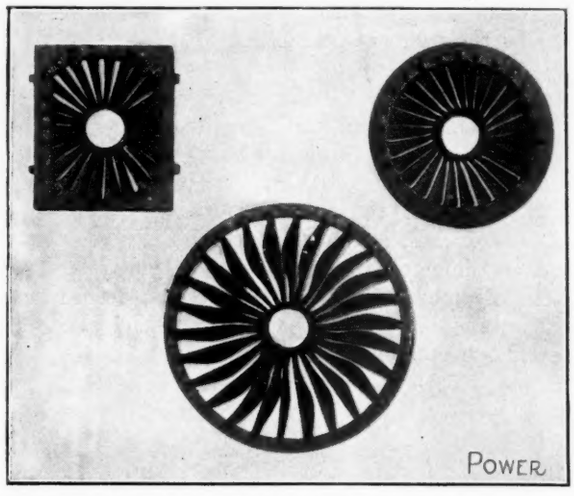


Fig. 9. Impeller Plates

Fig. 12 shows a truncated cone of sheet iron with no air openings in the side but at both ends, as shown by the arrows. No whirling motion resulted. Fig. 13 illustrates a flat disk or plate of sheet iron placed on the fire-

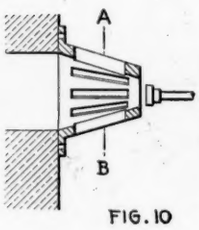


Fig. 10

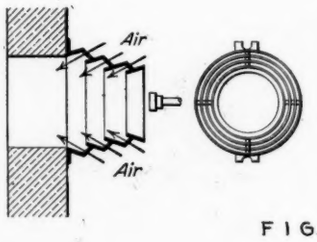
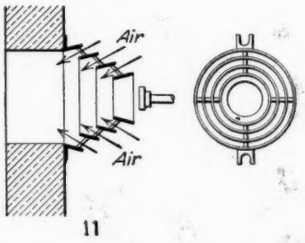


Fig. 11



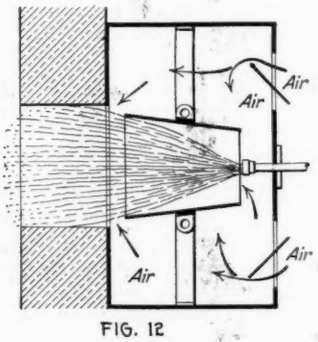


Fig. 12

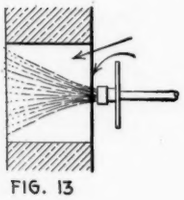


Fig. 13

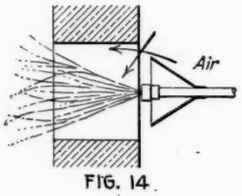


Fig. 14

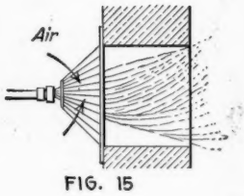


Fig. 15

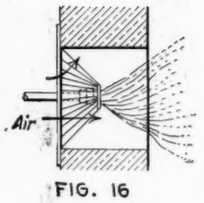


Fig. 16

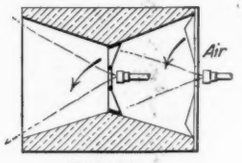


Fig. 17

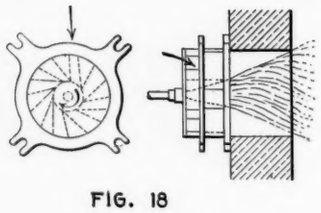


Fig. 18

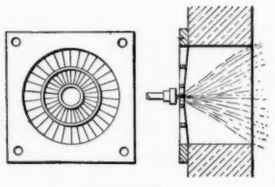


Fig. 19

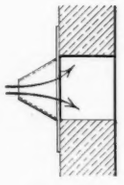


Fig. 20

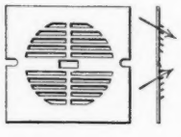


Fig. 21

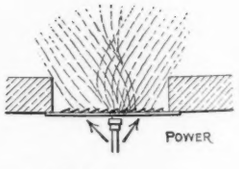


Fig. 22

*First part of this paper, which was read before the Society of Naval Architects and Marine Engineers, appeared in Power, Feb. 11, 1913.

room side of the burner tip to produce the effect of directing the air to the oil spray. The plate was tried in various positions and removed entirely, but no whirling motion was obtained. Fig. 14 is a sheet-iron cone placed

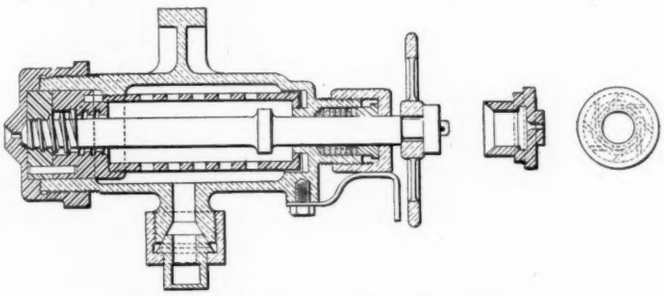


FIG. 23. THORNYCROFT BURNER

over the burner tip to direct the air. The cone was tried in various combinations with regard to the burner tip and opening to the furnace without obtaining a whirling motion. Fig. 15 represents a conical-bladed air impeller by which the air was given a whirling motion and directed in toward the axis.

Fig. 16 is the reverse of the last figure. The air is given a whirling motion but directed away from the axis. Fig. 17 is a venturi tube effect. The air is given a whirling motion by means of a flat-bladed air impeller. A large impeller was set at the large diameter at the en-

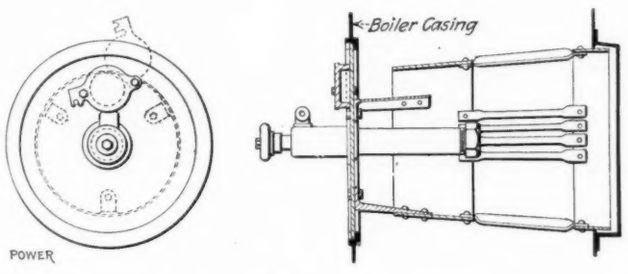


FIG. 23. THORNYCROFT BURNER

trance of the tube, and in another experiment a small impeller was set at the contracted diameter of the tube.

A device for giving the air a whirling motion by delivering it in a plane at right angles to the axis of the burner, tangentially to an air chamber surrounding the burner tip is shown in Fig. 18. Fig. 19 is an impeller giving the air a double twist, the outer blades driving it one way and the inner blades driving it the other.

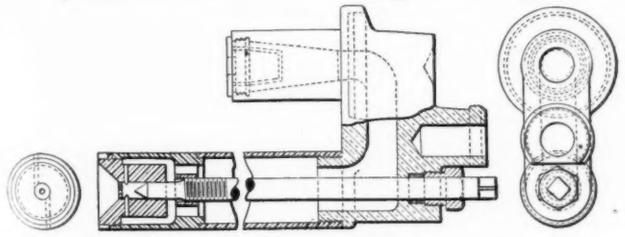


FIG. 26. SCHUTTE-KOERTING BURNER

Fig. 20 shows a long horizontal slot admitting the air into a chamber enlarging toward the furnace. This device was used in connection with the flat-spray atomizer. Fig. 21 shows a series of horizontal blades located on a flat plate over an area of circular form, the blades below the center driving the air upward and the blades above the center driving the air downward. This was used with a flat-spray burner. Fig. 22 shows a series of vertical blades on a flat plate of oblong shape. The blades below

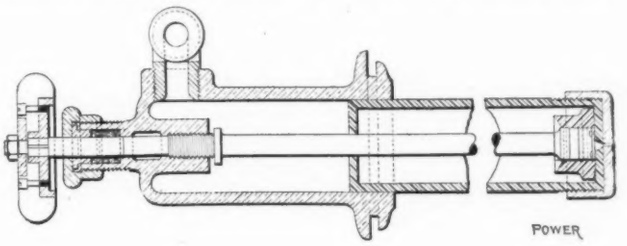


FIG. 24. NORMAND SYSTEM

the center drive the air to the left and the blades above the center drive the air to the right. This arrangement was used with a flat-spray burner.

PRINCIPAL SYSTEMS USED

In the following are briefly described the principal systems which have been installed in torpedo-boat destroyers.

THORNYCROFT, Fig. 23. In this burner the oil receives a whirling motion by passing through a spiral groove into a central chamber communicating with the outlet orifice of the tip. The tip fits on to a nozzle in which there is a cylindrical hole about the same diameter as the central chamber, and concentric with the axis of the burner. In the surface of this cylindrical hole a thread of square section is cut, of very slight depth at the end coinciding with the central chamber in the tip, but increasing rapidly in depth toward the direction of the opposite end of the burner at which the oil is admitted. A spindle fits into the cylindrical hole of the nozzle and on this spindle there is a corresponding thread, accurately fitting the thread of the nozzle and tapering to practically nothing at the end. When the spindle is screwed home the thread on the spindle bottoms on the tapered thread of the nozzle and no oil can get to the tip. As the spindle begins to be unscrewed, however, the marked taper of the two threads causes them to separate and form in combination a spiral groove, the sectional area of which rapidly increases as the spindle continues to be unscrewed. The central chamber is formed by the combination of the end of the spindle and the burner tip. The output of this burner is

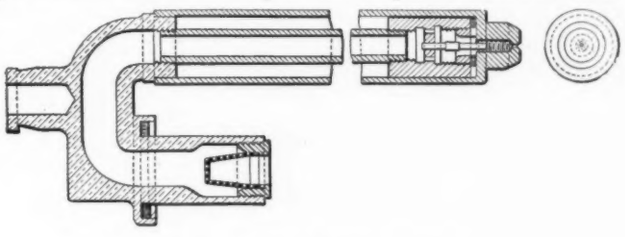


FIG. 27. FORE RIVER BURNER

controlled by the revolution of the spindle which regulates the area of the spiral oil passage.

The air for combustion is admitted through annular openings formed between concentric rings or short cylinders strung together to form a sort of truncated cone,

somewhat similar to the device shown in Figs. 18 and 19, except that in the present case the air is not directed toward the center.

NORMAND, Fig. 24. Eight small ducts deliver the oil tangentially to the central chamber formed by the combination of the tip and an adjustable spindle. The chamber is recessed so that the movement of the spindle does not in any way close or affect the ducts, its office being, besides forming one wall of the chamber, to close or throttle the outlet orifice. In the burner the ducts and outlet passage and orifice are made in a single piece which is held to the pipe or body of the burner by a clamp. The air-distributing device or tuyere consists of a truncated cone of sheet iron fitted on a portion of its surface with blades for giving the air a whirling motion, as shown in Fig. 25, on the preceding page.

SCHUTTE-KOERTING, Fig. 26. The tip of this burner is chambered out to receive a small spindle, less in diameter than the chamber except at the end, which is provided with a triple parallel thread which just fits the chamber and forms the oil to a smaller chamber at the end of the spindle communicating with the outlet orifice. The spindle is not adjustable, the burner capacity being varied entirely by controlling the oil pressure and temperature. This burner is fitted with a yoke and hand screw which holds it in position and provides a ready means for disconnecting. The air distributor is a truncated cone provided with longitudinal slots or openings which may be varied in area by means of a cover or register revolving on the outside and regulated by suitable mechanism. The air does not receive a whirling motion, the mixture with the oil spray being obtained by carrying a high air pressure and forcing it through the restricted area of the slots at high velocity.

FORE RIVER, Fig. 27. An adjustable spindle in this burner is arranged to throttle or close the outlet orifice and to vary the size of the central chamber to which the oil is delivered through two tangential ducts, and the burner is provided with a quick detachable arrangement for holding in place.

The air distributor is a cone provided with air slots in the side which give the air a whirling motion, the area of these slots being controlled by regulating mechanism. The angle of the cone is about 60 deg., which is much greater than that of any of the designs above described, and another difference lies in the fact that all the air enters through the slots and none around the burner. The slots, besides being so arranged as to give the air a whirling motion, are greater in area in the direction of the furnace.

SUMMARY

In the preceding pages the author tried to show that while the problem of oil burning presents some difficulties, particularly as regards admission of air, there is no mystery about the matter. A strong leaning toward simplicity, "horse sense," and some experience, are a combination reasonably sure of giving good results. On the other hand oil is not water, and the manufacturers of water sprinklers who have recently, under the stimulus of the times, entered the field of oil burning and steam generation, will find something more required than a table of steam properties and a few analyses of oil, and will certainly learn the fallacy of the theory that "It's all in the nozzle"

The Ferranti Steam Gas Turbine

For some years it has been known that Dr. S. Z. de Ferranti, past president of the Institution of Electrical Engineers, has been engaged in experimental work in connection with the steam turbine, with a view to the utilization of steam in the condition of an approximately perfect gas; that is, superheated far above its saturation point; but the details of his engine, and the degree of success that he had attained, were kept strictly secret. Now, however, in the course of the annual lecture in honor of James Watt, which he recently delivered at Greenock, Dr. Ferranti has taken the world into his confidence.

In the course of his lecture, he pointed out that there was a natural division between the steam turbine and the internal-combustion engine, the former being at its best when built for large powers, while the latter was most suitable for small powers, and referring to the strenuous efforts which are being made, especially in Germany, to develop the Diesel engine in large sizes for marine propulsion, he stated that few people had any conception of the failures and breakdowns which had repeatedly occurred with the big experimental engines that had been constructed, as these facts were carefully concealed from the foreigner. Turning to the steam turbine, he said that the economy increased as the temperature was raised, but mechanical difficulties were met with at high temperatures; however, he had commenced experimenting some years ago with a view to overcoming those difficulties and had now succeeded, after expending much time and money, in producing a turbine which was quite free from such troubles even at the highest temperatures, and under wide and rapid variations of temperature. Dr. Ferranti stated that in spite of the high temperature, his turbine runs with certainty with an extremely small clearance over the blades, diminishing leakage to a negligible quantity, and without any risk of stripping.

Not only is the steam superheated before admission to the turbine, but it is also resuperheated after the first expansion, and when exhausted from the turbine it is still in a superheated condition—whence the designation "steam-gas" which is applied to it. Before the steam enters the condenser it passes through a heater, by means of which a large portion of the heat energy is recovered. The blades are of mild steel, faced with a thin coating of pure sheet nickel electrically welded on, and are most accurately finished to shape by a process of step-by-step pressing, under very heavy pressure. The whole of the blading is electrically welded in position by automatic machinery so as to avoid straining, due to calking, which occurs at the high temperatures employed, and to prevent loosening, due to the same cause. Although the turbine is of the reaction type, a balance dummy is not employed, the end thrust being taken on a specially constructed thrust bearing, which prevents steam leakage.

A turbine built on these lines, of 5000 hp., has been running for some time, driving a large plant. When tested at two-thirds load, it is claimed to have produced a shaft horsepower on a consumption of 7 lb. of steam per hour, which is, of course, far in advance of anything previously attained. This could be supplied by an oil-fired boiler and superheated steam with a consumption of 0.625 lb. of oil per hp.-hr. As the turbine is constantly running on a variable load, it is difficult to ob-

tain an opportunity to carry out the full-load tests. Dr. Ferranti anticipates that when applied on a large scale, the system will be capable of attaining an overall thermal efficiency of 29 per cent. at a steam consumption of less than 6 lb. per hp.-hr.

It will be seen that in this turbine the Diesel oil engine has a formidable competitor in point of fuel consumption, as well as capital cost, which at present heavily handicaps the Diesel type. The large size of the experimental turbine also gives confidence in the results, which would have been lacking if only a small machine had been built.

Diehl Electrically Controlled Draft Regulation

A system of electrically controlled draft regulation has been evolved by the Diehl Manufacturing Co., Elizabethport, N. J. An electric motor in combination with a blower is shown in Fig. 1. The motor drive tends to materially lower the initial cost, because a high-speed fan may be used. One of the principal features of the outfit is flexibility of speed control, as the draft must be automatically regulated to suit conditions, and it is changeable at will.

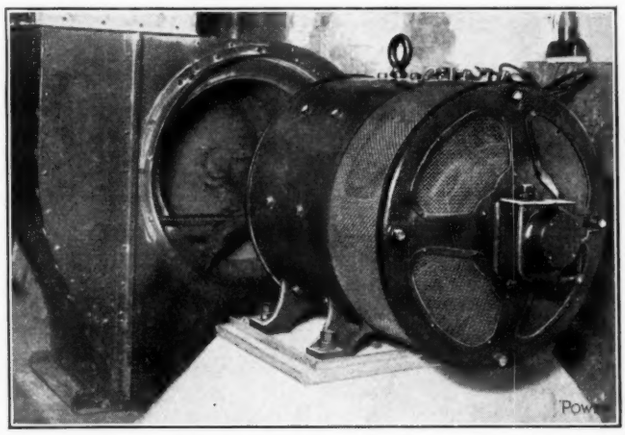


FIG. 1. MOTOR-DRIVEN FAN

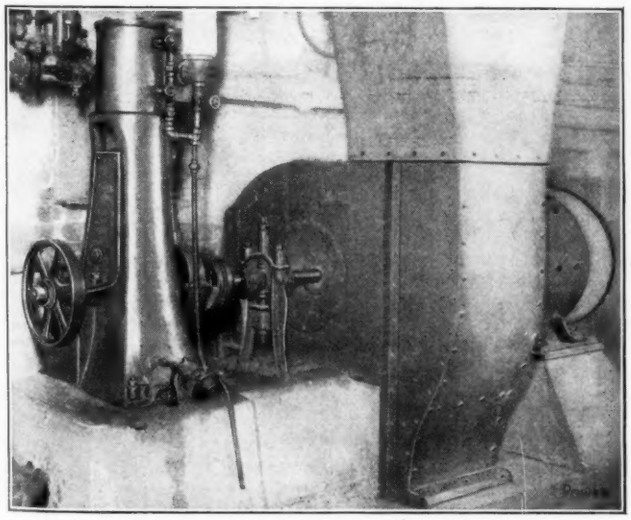


FIG. 2. MOTOR AND ENGINE-DRIVEN FAN

To provide against loss occasioned by a breakdown, duplicate motors can be arranged on either side of the fan, one only being coupled, and the spare motor ready to couple on at a moment's notice. This installation may be varied by the use of an electric motor and steam-engine relief unit, as illustrated in Fig. 2.

The motor is shunt wound and protected from dust and dirt. A steam-damper regulator is mounted alongside the electrical-control panel, as shown in Fig. 3. An automatic solenoid self-starter is shown below the steam gage; the change-over switch for either motor is shown alongside. Below are illustrated the chains, sprockets and counterweight which regulate the motor speed in accordance with the movement of the regulator attached to the wall.

The automatic action is as follows: Assuming that the steam pressure is high, the damper-regulator piston is at the extreme end of its upstroke, thus bringing the starting lever to the position shown, stopping the motor. As soon as the steam pressure drops, the regulator operates, transmitting its movement through the cord and chains to the two circular contacts shown under the rheostat.

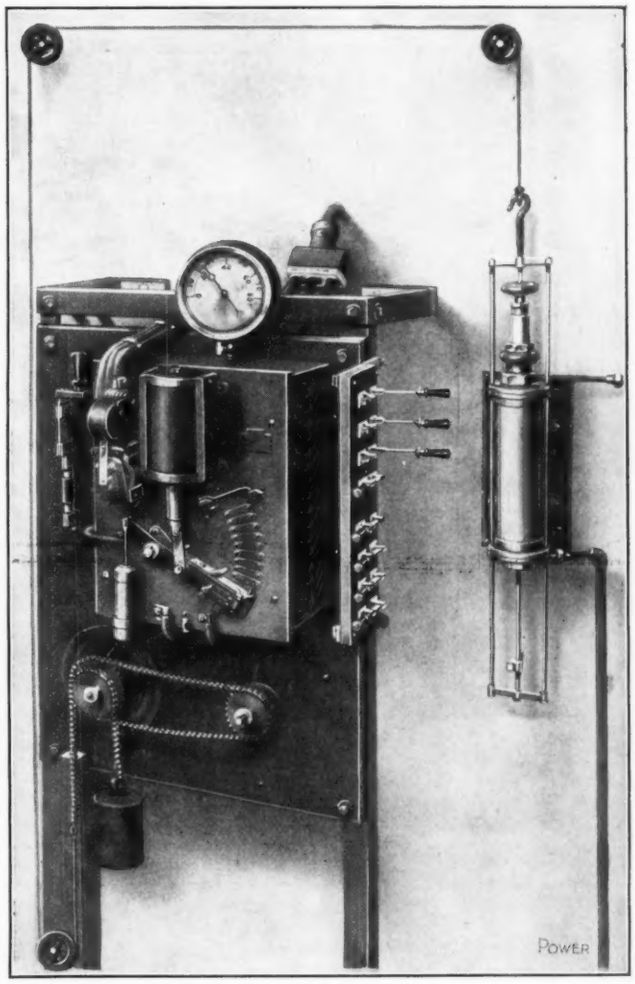


FIG. 3. DAMPER REGULATOR AND ELECTRICAL CONTROL

This movement closes the clapper switch and operates the automatic motor starter, giving the minimum speed available. The chains and sprockets transmit further movement of the damper regulator to the control arm of the motor field resistance attached behind the board

and not shown, the contact lever traveling over a series of 60 contacts, which movement increases the speed to any given point or maintains it at any one point, according to draft requirements. When the counterweight drops, the contact lever returns to the slow speed or "Full Off" position. A series of speed-limit switches is attached to the panel.

At times when the weather conditions are good and produce a strong natural draft, the motor is stopped an appreciable part of the time, resulting in a saving of power, but is ready to be instantly started when conditions alter.

Boiler Explosion at Pine Barren, Fla.

On Jan. 13, one of the two boilers in the plant of the McMillan Lumber Co., Pine Barren, Fla., exploded, killing the engineer and seriously injuring the fireman and three other persons.

The boilers were of the horizontal return-tubular type, connected to a common header and had only one popsafety valve to serve both boilers. They were operated at 100 lb. pressure and supplied steam for a planing mill and dry kilns.

According to our correspondent, the explosion was due to low water; both boilers were fed with injectors only. The boilers had been in service about nine years. Some of the tubes were coated with scale and others showed evidence of pitting.

The boiler that exploded, burst at the crown-sheet, tearing the plate for nearly half the circumference of the shell. The boiler seems to have been given a rolling motion around its longitudinal axis when it exploded, as circumstances indicated that the dome of this boiler struck the other with such force as to move it about 30 ft. from its setting.

Both heads were severed from the shell and seventeen of the sixty-four tubes remained in the heads. There was very little shearing of the rivets, the plates tearing away at the joints.

The engineer, who was in the boiler room at the time of the explosion, was found covered with débris; he died an hour later. The fireman was found pinned under the smoke-stack.

St. Louis Engineers Incitation Club

On Jan. 25, at the Nord-West Turn and Liederkranz Hall, the Engineers Incitation Club, composed of St. Louis stationary engineers, gave a very successful masquerade and theatrical ball. The proceeds will be used to prepare information for those interested in the work of the isolated plant.

The proposition is a vital one at the present time, says the St. Louis "Star," because of the nearing to completion of the Keokuk dam, which is to generate the power transmitted to St. Louis to supply factories and other places where electricity is used. The central station electric power plants have been making inroads on the privately owned or isolated steam and power plants, in the office and commercial buildings in St. Louis.

Many of the isolated plants have been closed, and current for power and light has been contracted for from central stations. The entrance of current from the Keokuk dam is expected to further encroach upon the work of the isolated or privately operated light, heat and power plant.

Members of the Engineers' Incitation Club combat the contentions of the public service corporations that they can furnish service and power cheaper than the commercial or office building plant, and it was to incite something better that the stationary engineers formed the club. During the last year the club completed several tests under varying conditions of service to arrive at the cost of isolated plant service with competent engineers and service rendered by central stations.

The Incitation Club claims that the isolated plant in the hands of a competent engineer can be operated more economically, give better service and always have help at hand for any incidental mechanical service. Current from central-station plants for light or power is one charge; heat and hot water service is a second and extra charge, and any maintenance or extra mechanical work must be done by outside high-priced mechanics. That engineers may ascertain the exact cost of the light, heat and power as well as the service rendered, the club has prepared a record book, covering the year 1913, which will enable the engineer to keep a record of the service rendered by the plant, as wall as the cost of every item entering into the production of the light, heat or power. These books were given to the men who attended the ball and free copies may be had of the members.

Electrical Baths for Edison Employees

Electrical baths will be one of the features of the new clubhouse of the Association of Employees of the New York Edison Co., which opened Feb. 4, at 113 East Twelfth St., New York City. All of the 3000 members of the association may now avail themselves of the benefits of electric bathing, along with the other privileges which the new clubhouse offers, such as bowling alleys, a music room, pool and billiard rooms, and a library of 1800 volumes.

William T. Dempsey, who has charge of all of New York City's electric street lighting, is president of the association, which has as its chief objects, welfare and educational work. Its members may avail themselves of a four-year course of instruction in electrical engineering under competent teachers without any cost to themselves, a thoroughly equipped laboratory being maintained for this purpose. Owing to its complete and unusual electrical equipment, this new clubhouse might almost be called the electrical clubhouse.

SOCIETY NOTES

The fourth concert, banquet and dance of the combined associations of the N. A. S. E., of Philadelphia, Penn., was held at Lulu Temple, Thursday evening, Jan. 30. The combination comprised Quaker City No. 1, Tacoma No. 9, Merrick No. 12 and Northeast No. 20.

There were upward of six hundred persons present, among them being many prominent engineers and representatives of supply houses. From 7:30 to 8 o'clock there was an organ recital followed by an entertaining vaudeville performance, at the conclusion of which the company adjourned to the banquet hall, where an appetizing dinner was served. Dancing concluded the evening's enjoyment.

A lecture and demonstration on smoke-recording, flue-gas analyzing and soot cleaning was given on Thursday evening, Jan. 16, at Masonic Temple Building, under the auspices of the Decatur Association, N. A. S. E., at Decatur, Ill. F. A. Moreland, of the G. L. Simmons Co., Chicago, assisted by Anson Gale, delivered the lecture.

PERSONALS

Richard S. Buck has retired from the firm of Sanderson & Porter to accept the position of chief engineer of the Dominion Bridge Co., Canada. Seton Porter has been made a partner in the first-named company.

E. T. Adams, former manager and chief engineer of the gas and mill engine department of the Allis-Chalmers Co., Milwaukee, Wis., and recently president of the Wisconsin Engine Co., Milwaukee, has been appointed chief engineer of the Rumeley Co., La Porte, Ind.

Where mine power plants are located near or over the mine itself an easy and economical method of disposing of the ash is to arrange a tunnel under the fire boxes, with a slope of not less than ⅜ in. to the foot. Connect this with a bore-hole and wash the ashes down the latter, with mine water, where they may be used for flushing abandoned workings if desired.—"Coal Age."